IMP. PUB.
7 JUL. 1924
AGRICULTOM.

THIRTY-NINTH ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

FOR THE

YEAR ENDED JUNE 30, 1916

Bull. 231-236

THIRTY-NINTH ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

CONDUCTED JOINTLY BY THE

N. C. DEPARTMENT OF AGRICULTURE

AND THE

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

FOR THE

YEAR ENDED JUNE 30, 1916

INCLUDING

Bulletins Nos. 232, 233, 234, 235, 236

RALEIGH
EDWARDS & BROUGHTON PRINTING COMPANY
STATE PRINTERS
1917

LETTER OF SUBMITTAL

RALEIGH, N. C., June 30, 1916.

To His Excellency, LOCKE CRAIG,
Governor or North Carolina.

SIR:—I have the honor to submit herewith report of the operations of the Agricultural Experiment Station, conducted jointly by the North Carolina Department of Agriculture and the North Carolina College of Agriculture and Mechanic Arts, for the year ended June 30, 1916. This work is under the immediate direction of the "Joint Committee for Agricultural Work" provided for in chapter 68 of the Public Laws of 1913, and the report is made in accordance with the requirements of the Act of Congress approved March 2, 1887, and known as the Hatch Act.

Very respectfully,

B. W. KILGORE,
Director.

TABLE OF CONTENTS

	PAGE
Letter of Submittal	3
General Summary of the Work of the Station During the Year	7
Report of the Division of Agronomy	13
Report of the Division of Chemistry	19
Report of the Division of Animal Industry	21
Report of the Division of Entomology	48
Report of the Division of Horticulture	52
Report of the Division of Veterinary Science	55
Report of the Division of Plant Pathology and Bacteriology	58
Report of the Division of Markets and Rural Organization	59
Report on Drainage	66
Financial Report	69

BULLETINS:

No. 232—Results of Variety Tests of Wheat, Oats, and Rye.

No. 233—Common Diseases of Poultry.

No. 234—Farm Drainage in North Carolina.

No. 235—Some Further Studies of Chick Mortality; When to Feed the Baby Chick.

No. 236—The Prevention and Control of Erosion in North Carolina with Special Reference to Terracing.

BOARD OF AGRICULTURE

*W. A. Graham, *Chairman*, Raleigh

F. P. Latham	Belhaven	*A. T. McCallum	Red Springs
C. W. Mitchell	Aulander	*C. C. Wright	Hunting Creek
*R. L. Woodard	Pamlico	William Bledsoe	Gale
*Clarence Poe	Raleigh	W. J. Shuford	Hickory
R. W. Scott	Haw River	A. Cannon	Horse Shoe

BOARD OF TRUSTEES OF THE COLLEGE

Governor Locke Craig, *Chairman*

M. B. Stickley	Concord	*T. T. Thorne	Rocky Mount
T. T. Ballinger	Tryon	*C. W. Gold	Greensboro
W. H. Williamson	Raleigh	T. E. Vann	Como
*O. L. Clark	Clarkton	P. S. Boyd	Mooresville
Everett Thompson	Elizabeth City	W. E. Daniel	Weldon
R. H. Ricks	Rocky Mount	*W. H. Ragan	High Point
O. Max Gardner	Shelby	W. B. Cooper	Wilmington
M. L. Reed	Biltmore	J. P. McRae	Laurinburg

W. C. Riddick (President College), West Raleigh

STAFF OF THE AGRICULTURAL EXPERIMENT STATION AND EXTENSION SERVICE

Administration

B. W. Kilgore — Director of Experiment Station and Extension Service
C. B. Williams — Vice-Director Experiment Station
R. W. Collett — Assistant Director, Branch Stations
F. H. Jeter — Agricultural Editor
A. F. Bowen — Bursar
Miss Mary S. Birdsong — Secretary to Director

Agronomy

C. B. Williams	Chief in Agronomy	[3]R. B. Hardison	Asst. in Soil Survey
J. K. Plummer	Soil Chemist	S. O. Perkins	Asst. in Soil Survey
W. F. Pate	Agronomist—Soils	L. L. Brinkley	Asst. in Soil Survey
E. C. Blair	Assistant Agronomist—Soils	F. N. McDowell	Asst. in Soil Survey
H. D. Lambert	Assistant Agronomist—Soils	[2]E. S. Vanetta	Asst. in Soil Survey
R. Y. Winters	Plant Breeding	[1]E. H. Mathewson	Tobacco Expert
[1]J. H. Hall, Jr.	Assistant in Plant Breeding	A. R. Russell	Asst. in Field Experiments
[1]V. R. Herman	Assistant in Plant Breeding		

Chemistry

W. A. Withers	Chemist	J. Q. Jackson	Assistant Chemist
F. E. Carruth	Assistant Chemist	E. S. Dewar	Assistant Chemist
J. A. Mullen	Assistant Chemist	E. B. Hart	Assistant Chemist
J. M. Pickel	Feed Chemist	F. C. Wiggins	Assistant Chemist
W. G. Haywood	Fertilizer Chemist		

Entomology

Franklin Sherman, Jr.	Chief in Entomology	S. C. Clapp	Assistant Entomologist
Z. P. Metcalf	Entomologist	R. W. Leiby	Assistant Entomologist
		[6]George H. Rea	Bee-keeping

Horticulture

W. N. Hutt	Chief in Horticulture	C. D. Matthews	Assistant Horticulturist
J. P. Pillsbury	Horticulturist	B. Szymoniak,	Demonstrator in Fruit and Truck Crops
L. R. Detjen	Assistant Horticulturist		
R. G. Hill	Assistant Horticulturist		

Animal Industry

Dan T. Gray	Chief in Animal Industry	[3]J. A. Arey	Assistant in Dairy Farming
R. S. Curtis	Associate in Animal Industry	[3]F. R. Farnham	Assistant in Dairy Farming
W. H. Eaton	Dairy Experimenter	[3]J. L. Graybill	Assistant in Dairy Farming
B. F. Kaupp,	Poultry Investigator and Pathologist	[3]F. T. Peden	Assistant in Beef Cattle
[3]A. J. Reed	Dairy Farming	[3]A. L. Jerdan	Assistant in Beef Cattle
[3]B. P. Folk	Pig Club Agent	[3]L. I. Case	Assistant in Beef Cattle
[3]A. G. Oliver	Poultry Club Agent	Earl Hostetler,	Assistant in Beef Cattle and Swine
Stanley Combes	Assistant in Dairy Farming	Dan M. McCarty	Asst. in Animal Nutrition

Plant Pathology

F. A. Wolf	Plant Pathologist	E. E. Stanford	Assistant—Bacteriology
R. O. Cromwell	Assistant—Plant Diseases		

Drainage

[4]H. M. LYNDE.....Senior Drainage Engineer F. R. BAKER.....Assistant Drainage Engineer

Veterinary

G. A. ROBERTS.....Veterinarian

Markets and Rural Organization

W. R. CAMP.....Chief, Division of Markets
E. E. CULBRETH.....Assistant Superintendent of Credit Unions

Farm Management

J. M. JOHNSON.....Farm Management

Branch Stations

F. T. MEACHAM.....Assistant Director Iredell Branch Station, Statesville
J. H. JEFFRIES.....Assistant Director Pender Branch Station, Willard
C. E. CLARK.....Assistant Director Edgecombe Branch Station, Rocky Mount
[1]E. G. MOSS.....Assistant Director Granville Branch Station, Oxford
S. F. DAVIDSON.....Assistant Director Buncombe and Transylvania Stations, Swannanoa

Farm Demonstration Work

C. R. HUDSON.....State Agent
E. S. MILLSAPS.....District Agent, Western District
T. D. MCLEAN.....District Agent, Central District
R. W. FREEMAN.....District Agent, Eastern District

Boys' Agricultural Clubs

T. E. BROWNE.....State Agent and Rural Supervisor
S. G. RUBINOW.....Assistant State Agent
A. K. ROBERTSON.....Corn Club Agent

Home Demonstration Work

MRS. JANE S. MCKIMMON.....State Agent
MISS MINNIE L. JAMISON.....Assistant in Home Demonstration Work
MISS GRACE E. SCHAFFER.....Assistant in Home Demonstration Work

---

The members marked with * are members of the Joint Committee for Agricultural Work, and the Experiment Station and Extension Service are under their direction.

[1]In cooperation with the U. S. Department of Agriculture, Bureau of Plant Industry.
[2]In cooperation with the U. S. Department of Agriculture, Bureau of Soils.
[3]In cooperation with the U. S. Department of Agriculture, Bureau of Animal Industry.
[4]In cooperation with the U. S. Department of Agriculture, Office of Public Roads and Rural Engineering.
[5]In cooperation with the U. S. Department of Agriculture. Office of Farm Management.
[6]In cooperation with the U. S. Department of Agriculture, Bureau of Entomology.

THIRTY-NINTH ANNUAL REPORT

OF THE

North Carolina Agricultural Experiment Station

For the Year Ending June 30, 1916

B. W. Kilgore, *Director.*
F. H. Jeter, *Agricultural Editor.*

This report covers the work of the Station from July 1, 1915, to June 30, 1916.

The year through which the North Carolina Agricultural Experiment Station has just passed has been one of real progress and development. The influence of the work which has been done and which is still under way is reflected in a substantial betterment of agricultural conditions throughout the entire State.

In performing the large and varied service to the agricultural interests, there are forty-eight workers who are engaged in the investigational work which the Station is carrying on. The growth in means, number of workers employed, services performed, and influence has been rapid, in fact, far more so, it is believed, than was anticipated by any one when the joint agricultural work was undertaken by the State Department of Agriculture and the College of Agriculture and Mechanic Arts.

Few changes in the staff have occurred during the year. Dr. F. A. Wolf was secured as a successor to Prof. H. R. Fulton, Chief of the Division of Plant Diseases, who went to the Federal Department of Agriculture. In the Divisions of Agronomy and Animal Husbandry some minor changes in assistants have occurred.

In the work of the Experiment Station and Extension Service it has not been possible to keep complete records of all the various activities of all the workers, but those which have been kept show very clearly how closely the work is in touch with the farmers of the State. The work has not been confined to actual experiments and demonstrations in the laboratories and on the experimental plots, but it has reached out over the State to the branch stations, local farms and the farm homes, carrying a knowledge of better living, better farming, and a higher social life to the farm women, men, girls, and boys on the farm. Numbers of public meetings have been held where the people have become interested in the practical, scientific information given as well as in the demonstrations held. Bulletins, periodicals, multigraph matter, and special articles have been sent out in answer to requests over the entire State; and business men, corporations, and others have enlisted their aid in the

undertaking to make a more pleasant and more remunerative farming profession. The records show that the work is so organized that almost every activity and phase of farming in North Carolina is actually demonstrated, not only by personal contact, but by correspondence, bulletins, and other timely publications, and it is apparent that good results are being obtained.

The records show that the workers have traveled approximately 456,453 miles during the year, and have reached 885,792 people. Of course, some of these people have been seen a number of times, but, on the other hand, many who were seen have influenced many others to follow the improved farming methods found by experimentation, and it may be said with a good degree of accuracy that one million people have been reached during the year by the combined agricultural service of the Experiment Station and Extension Service.

The program of investigative work is being developed in such a way as to meet the needs of our growing agriculture and to furnish information where it will be most helpful. A brief summary of the work of the different divisions, showing the main undertakings in which the workers are engaged, is given in the reports of divisions which follow.

AGRONOMY.

In Agronomy three main phases of work are being considered. These are soil survey, soil fertility studies, and plant breeding. Most of the experimental work is based upon the soil survey, as the other two phases, to be of the greatest value, must be based upon the types of soils.

The soil fertility work is being done both in the field and in the laboratories, with different types of soils, to determine their chief needs and deficiencies for profitable crop yields under a proper system of soil management. Crop improvement and adaptations to different soils in different sections of the State are also receiving consideration.

Permanent pasturage and hay crops for different sections of the State are being worked out with the different legumes and grasses best suited for the two purposes.

The selection and establishment of certain strains of different crops which make their maximum growth and production in different parts of the State continues to be the main feature of the plant breeding work.

Investigations into the uses of the soybean and its products in the commercial work has been a special feature of the work of the Agronomy Division during the past year. Considerable progress has been made and the crop has attained greater popularity as a summer legume as a result. Extension work with the bean is now being conducted, and during the past year 100,000 or more bushels were crushed by the oil mills of the State in beginning a new market for the farmers for this product.

CHEMISTRY.

Work in this Division has been continued during the year along the same lines as heretofore. The toxicity of cotton-seed meal and the nitrification of soils have received the principal attention of the workers. Several articles have been published in regard to the toxic principle of the meal, and the question as to whether or not it is Gossypol, as has been found by this Station, has been widely discussed by other investigators.

ANIMAL INDUSTRY.

The work of investigation in Animal Industry is being conducted with swine, beef cattle, sheep, dairy cattle, horses and mules, and poultry. The undertakings are outlined so as to cover the main questions which have arisen in connection with these industries in the State.

Splendid results have attended the manufacturers of cheese in the mountains of the western part of the State, five factories having been built, and there is now a demand for aid in the construction of more of these factories than the Station is able to supervise. A cheese of excellent quality is being manufactured, and has found a ready sale on the market at prices above that which has been paid for other cheese. Because of the conditions where this cheese is being manufactured, this work is considered among the best conducted by the workers during the year, and is a step forward toward the establishment of a new industry for the State. This will be encouraged and followed until it is on a good footing. Investigations in the creamery and dairy industry have made good progress. A plant has been established at the College for the benefit of the farmers adjacent to the Central Station and for the study of problems connected with the creamery industry.

The work with poultry continues to be very satisfactory. Some twenty-one projects are being studied in poultry, and the findings are being given publicity.

ENTOMOLOGY.

In Entomology, nine principal projects are under investigation. These are: the investigation of laundry soap as a remedy for Aphides, survey of the insect life of the State, the spraying of peaches and potatoes, a study of the pecan insects, a study of the Corn-stalk Borer, Corn Bill Bug, Gloomy Scale, and Cowpea weevils. The experiments with peach spraying have been followed during the second year, and the potato spraying project has been carried through the third. The study of the pecan insects has been in progress since 1913. One year's work with the Cornstalk Borer has been completed. Studies of the Corn Bill Bug have been practically finished and work is continuing on the Gloomy Scale, affecting shade trees, and the cowpeas and bean weevils with a view to determining their life-history and means of combating them.

Under the supervision of this Division a bee-keeping project has been added for the purpose of promoting and improving the bee-keeping industry in the State.

HORTICULTURE.

The growth of trucking and orcharding gives importance to the work of the Division of Horticulture. In addition to the efforts which are being made to study the various truck and fruit crops, special work is being done in coöperation with the United States Department of Agriculture to improve the Scuppernong type of grape. This work is being carried to the point where new ones are being produced which will have greater commercial value.

Valuable results are being obtained from a study of the pecan industry. This work has now been under way for nine years and considerable data have been collected. The work of breeding new varieties is being pushed and a number of crosses has been made with the hope of getting better kinds.

A study is being made in an effort to produce early freestone varieties of both white and yellow-flesh peaches, and also varieties which are hardier in the bud. In this connection a number of foreign varieties are being studied.

The study of the thermal belts of Western North Carolina and their relations to fruit production is now in its fifth year, and good progress in obtaining results is being made.

Considerable work is under way in a study of sweet and Irish potatoes, including studies of varieties, fertilization and methods of storing.

A study of the self-sterility in dewberries and blackberries has been completed during the year and is being published as Bulletin No. 11 in the Technical series. This study has established several important facts in regard to the sterility and fertility of different varieties and crosses. The study of the transmission of characters in hybrids of Rotundifolia grapes has progressed favorably, and a manuscript on the inheritance of sex in the Vitis Rotundifolia is being published as Technical Bulletin No. 12.

VETERINARY SCIENCE.

In this Division the so-called "contagious abortion" infection has received the principal attention of the workers. The trouble has been found in a large number of the herds of cattle in the State, and similar infections have been found quite prevalent in horses, swine, and sheep. The major part of the studies during the past year has been done with dairy cattle.

An effort is being made to determine the effects or results of the infection, the extent or prevalence, the means and methods of detecting it, and measures for control of the effects if not of the infection itself. The disease has been found to be general over the State.

PLANT PATHOLOGY AND BACTERIOLOGY.

Work has been conducted along the lines of soil bacteriology, apple root rots, lettuce drop, watermelon wilt, and tobacco wilt. The work in soil bacteriology, in coöperation with the Division of Chemistry, is being conducted along the same lines as previous years, special attention being given to the relation between the rate of nitrification and the character of nitrifying solutions. With the apple root rots, field and laboratory studies are being made with one of the organisms productive of the rot. Comparative studies are being made with the Sclerotinia attacking lettuce and the one affecting clovers and alfalfa, and considerable data have been secured on the relationship of the organisms.

The tobacco wilt studies are being made in coöperation with the United States Department of Agriculture. It has been found during the year that crop rotation is one of the most successful methods of controlling the disease.

MARKETS AND RURAL ORGANIZATION.

In the main, the Division of Markets has concerned itself with aiding the citizens in the marketing and financing of their products and farming operations. This has been accomplished through the publishing of a weekly price report, a daily wire service for localities specializing in the growing of some of the perishable products, the listing of sellers, buyers and receivers of farm products, the organization of Credit Unions and Farm Loan Associations, and of farmers for marketing coöperatively by the grading, warehousing and marketing of cotton, and by installing standard methods of accounting in different farm enterprises. In all of these matters considerable progress has been made.

Twenty-one counties responded to the request for a $300 appropriation by the board of county commissioners for the purpose of investigating the grading, warehousing, and marketing of cotton in the different cotton growing counties, and grading offices were established at Charlotte, Fayetteville, New Bern, Raleigh, Tarboro, Weldon, and Wilson.

DRAINAGE.

The work of Drainage has been confined to three general lines: The improvements of farm lands now under cultivation by the drainage (mainly with tile), collection of general and technical data on drainage, and preliminary and reconnaissance work.

A considerable number of farms have been improved during the past year by careful tile drainage and terracing. Some good data are being collected in Wilson County and in Iredell County on the determination of run-off in tile drains.

PUBLICATIONS.

In addition to the multigraph circulars sent out to special mailing lists, five regular bulletins and six circulars have been printed and distributed. Four issues of the Farmers' Market Bulletin also were printed and distributed.

Following are the publications issued:

BULLETIN

232. Results of Variety Tests of Wheat, Oats, and Rye. *By G. M. Garren.*
233. Common Diseases of Poultry. *By B. F. Kaupp.*
234. Farm Drainage in North Carolina. *By H. M. Lynde.*
235. I. Some Further Studies of Chick Mortality.
II. When to Feed the Baby Chick. *By B. F. Kaupp.*
236. The Prevention and Control of Erosion in North Carolina with Special Reference to Terracing. *By F. R. Baker.*

CIRCULAR

28. The Use of Lime on the Farm. *By C. B. Williams.*
29. Feeding Skimmilk, Buttermilk, and Whey to Hogs. *By Dan T. Gray.*
30. Oats for North Carolina. *By C. B. Williams.*
31. Soybean Growing in North Carolina. *By C. B. Williams.*
32. Increasing Our Crop Yields by Seed Selection on the Farm. *By R. Y. Winters.*
33. Cow Records Pay. *By A. J. Reed.*

FARMERS' MARKET BULLETIN—4 issues.

The reports of the heads of the several Divisions and financial statement follow:

REPORT OF THE DIVISION OF AGRONOMY.

To the Director:

The activities of the Division have been chiefly along three lines: Soil Survey, Soil Fertility, and Plant Breeding.

The work of the soil survey is the basis on which most of the other experimental work is carried on. It has been found that work in plant breeding and soil fertility, in order to be of the greatest value, must be based upon types of soil as the plant-food deficiencies, and hence the plant-food requirements, as well as the plant adaptations, are frequently different for different types of soil.

In the soil fertility studies it is planned to determine the chief plant-food deficiencies of the soils and the most profitable means of supplying these deficiencies to different crops.

In the plant-breeding work it is planned to select and establish certain strains of the different crops that are best adapted for growth on the different soils in the various sections of the State.

In the summary given below some of the results secured in the various lines of work carried on by the Division of Agronomy of the Station are recorded. These are mainly as follows:

MAIN WORK IN PROGRESS.

(1) Soil survey to establish and map the various types of soil occurring in the several counties of the State.

(2) Soil fertility work in the field and in the laboratory with different types of soil to determine their chief needs and deficiencies for profitable crop yields under a proper system of soil management.

(3) Crop improvement and adaptation to different soils and sections of the State.

(4) Determination of the most suitable grasses and grass mixtures, combined with clovers and other suitable legumes, for permanent pasture and for hay purposes in different sections of North Carolina.

(5) Investigative work in soybean growing and in a better and more complete utilization of the soybeans themselves by inducing cotton-oil mills to crush the beans.

WORK FINISHED AND RESULTS SECURED.

Soil Survey.—During the year soil survey work has progressed satisfactorily. During the past summer surveys of Wayne and Columbus were completed, and work in Anson, Alleghany, and Davidson was begun during the fall. Work in these latter counties was finished during the winter, and the three parties working in the State took up work in Halifax, Harnett, and Hertford counties. At present, the field work is

being done by three men each from the Federal and State Departments of Agriculture. It is planned during the summer to start surveys of Cleveland, Stanly, and Orange counties.

RESULTS OF SOIL FERTILITY STUDIES.

Chemical and Petrographic Examinations.—In the chemical and petrographic studies of the soils of the State, the following fundamental points of importance have been brought out:

(1) Wide variations in the total amount of the elements of plant food have been shown to exist between the soils of the Appalachian Mountains, Piedmont Plateau, and Atlantic Coastal Plain. The soils of the first physiographic province are better supplied with phosphoric acid, potash, and lime than are those of the other two provinces which compose the State. Those of the Piedmont Plateau are, as a rule, amply supplied with potash and lime and with phosphoric acid in rather large amounts in some cases. On the other hand, the soils of the Coastal Plain south of Albemarle Sound are markedly deficient in all essential elements of plant growth.

Nitrogen is usually low in a majority of the soils of all three sections of the State.

(2) Petrographic studies of these soils correlate markedly with the chemical studies. The petrographic studies show that the question of topography plays an important part in the chemical composition of soils. Those soils of the mountains are formed from the same or similar rock as are those of the Piedmont section, yet almost invariably the mountain soils are richer in minerals other than quartz, especially those carrying phosphoric acid, potash, and lime. In the mountains the forces of erosion have not allowed the soil mantle to become as well defined as in the Piedmont province, consequently there is greater preponderance of the minerals found in the parent rock when the superficial covering has been removed. The Coastal Plain soils are markedly deficient in minerals except quartz, which is in accord with the ultimate chemical analyses.

(3) In coördinating these studies with the field tests, using various crops as indicators for measuring the relative densities of the soil solution, close relationships appear to exist between the chemical and mineral composition of the soils of each province and their requirements for the chemical elements found in the usual fertilizer mixture. Nitrogen being low in a majority of the soils of the State, it is either the first or second element required by all the soils under experiment.

(4) Phosphoric acid is the constituent most needed in the western soils. An average of many analyses shows that as a rule this constituent is found in larger quantities here than in the Coastal Plain soils, yet it does not appear to be needed so badly on the latter. This is undoubtedly due to the fact that the western soils are of much finer

texture and the absorption much greater; therefore, there is greater competition between the soil and plant for this material than occurs in the sandy soils of the eastern section.

(5) Potash and lime are abundant in the Piedmont and Mountain provinces. Field tests show that with common crops, except legumes, potash cannot usually be used artificially at a profit. Here micas furnish much of the potash contained therein. Lime has not produced the results here as it has done down in the eastern portion of the State. Plagioclase feldspar, augite, and hornblende are more abundantly found in the upper sections. With the soils of the east, potash is one of the limiting chemical elements, and felspathacic material is its principal source.

(6) More data are needed on the question of the relative availability of plant food when supplied in the combinations of the various soil-forming minerals. The indications are that micas furnish a better supply of potash than feldspars, and plagioclases and hornblende carry lime more easily soluble than epidote, garnet, etc. Pot experiments are now under way at the Station with the view of throwing some light on this important question.

Field Work with Mountain Soils.—Four distinct types of soil are being studied in the mountain section of the State, viz.: Porter's clay, Porter's loam, Toxaway silty loam, and Toxaway loam.

(1) All four types show that phosphoric acid is needed first, and potash shows no gain with different crops, except where complete fertilizer is used and large crops produced. Lime alone shows gains on leguminous crops, and when used with complete fertilizer a gain is made.

(2) On Porter's clay and Porter's loam nitrogen is second in importance to phosphoric acid, and has to be supplied to produce good crops.

(3) Toxaway loam and Toxaway silty loam need nitrogen for best results, but not so much as the upland mountain soils to produce remunerative crops.

Field Work with Piedmont Soils.—Cecil clay near Charlotte, Cecil clay loam near Statesville, and Cecil sandy loam near Gastonia all show phosphoric acid is the limiting constituent of plant food, with nitrogen coming second. Very little benefit is derived from potash, except where used in a complete fertilizer.

(1) The tests on the Iredell loam near Charlotte show that nitrogen is the first element of plant food needed, with potash and lime next. Although a complete fertilizer with lime gives best returns where phosphoric acid alone is used, no increase is secured. This seems to be the only type of soil thus far studied in the Mountain and Piedmont sections in which phosphoric acid does not show up to be one of the limiting constituents in crop growth.

(2) Alamance silt loam near Monroe, Durham sandy loam near Oxford, and Norfolk coarse sand near Hoffman all show nitrogen to be

the most needed element of plant food with phosphoric acid and potash, showing good yields when used with phosphoric acid and nitrogen. In fact, for large crops a good supply of all of the plant-food constituents with lime is needed, as well as an increased supply of vegetable matter. Hence all of the constituents seem to be more or lesss limiting factors in producing maximum crops.

(3) On the Cecil clay soils, potash either gives no gain or depresses the yields. This may be accounted for by the increase of the amount of potash in the soil solution. Enough of this constituent evidently is present for present crop yields on the type.

(4) At the Central Test Farm on other phases of Cecil series of soils experiments show that nitrogen is the chief limiting element of plant food for large yields of crops, with additions of phosphoric acid needed for best crops. Potash is of least importance.

Field Work with Coastal Plain Soils.—With soils of this section, the following types of soil have been studied long enough for fair conclusions to be drawn with reference to their greatest needs: The Portsmouth fine sandy loam at Pantego, Portsmouth silt loam near Edenton, Norfolk fine sandy loam near Kingsboro, Norfolk sandy loam at Elizabeth City, Norfolk sand near Greenville, and muck near Moyock have been studied.

(1) With the exception of muck, nitrogen is the limiting element of plant food with all these eastern soils, with potash and phosphoric acid needed to produce good gains in crop yields.

(2) The results on Norfolk sandy loam at Elizabeth City have shown that phosphoric acid comes before potash in importance for this type of soil.

(3) On the muck soil, lime seems to be of first importance, then phosphoric acid, potash, and nitrogen follow in the order given. The use of nitrogen, potash, and phosphoric acid give best returns when used in connection with lime.

(4) Norfolk sand at Greenville gives evidence of needing humus-forming material before any fertilizer can be used with profit.

(5) With peaty soils, the addition of potash and phosphoric acid seems to have a depressing effect so far when used alone or in combinations without lime.

(6) Taking the State as a whole, one of the materials of greatest importance for good crop yields is decaying vegetable matter incorporated into all the agricultural soils. After this is done, and it will furnish a good supply of nitrogen, phosphoric acid in an available form is the constituent of first importance to be supplied, except in the southeastern portion of the State, where potash is of extreme importance for intensive farming.

RESULTS OF BREEDING EXPERIMENTS.

(1) In breeding work with cotton, it has been found from a large number of selections that Selection No. 29 is the best yielder thus far

secured. It produced 252 pounds of seed cotton more per acre in 1915 than the unselected seed from which the selected strains came. It led in the variety test at the Station farm by 94 pounds of seed cotton per acre.

(2) In coöperative cotton improvement work at Aberdeen last year with a long staple upland variety, an uniform strain was secured that gave a staple $1\frac{5}{16}$ inches in length, and compared favorably in yield with the short-staple cottons grown in that vicinity.

(3) In community cotton improvement work at Crisp, in Edgecombe County last year, much interest was shown in the work, and the farmers coöperating were much pleased with the results secured. A strain of cotton introduced in the community produced 158 pounds of lint more per acre than did the variety most generally grown in that community.

(4) In ear-to-row coöperative corn-breeding work with W. L. Wyatt of Wake County, the yields ranged between 23.1 and 58.7 bushels of shelled corn per acre from the different plantings from selections made in the field during the previous fall. The ten best selections average 54.2 bushels, while the average yield for the whole field of selected seed was 42 bushels per acre. The higher yields of some of the strains indicate the value of such selections. The best yielding strain produced at the rate of 16.7 bushels per acre more than the average of all the selections. Considering the average for the best ten selections and the average for the whole lot, we have a yield of 12.2 bushels per acre in favor of the ten best selections.

(5) In variety tests with soybeans in different parts of the State it has been found that for the Eastern and lower Piedmont sections the Mammoth Yellow and Tokyo are leaders, and for the upper Piedmont and mountains the Haberlandt and Wilson for seed production. For hay production the Virginia is superior to any variety thus far found for any section of the State.

(6) In coöperative soybean experiments last year with F. P. Latham of Beaufort County, the Tokyo variety showed up so favorably as a yielder of seed that it will be used this year to replace, to some extent at least, the varieties ordinarily grown in that section for seed production. These tests, too, brought out the value for early pasturage for that section of the Haberlandt and Black Eyebrow varieties. Because of their earliness, these two varieties come on at a time when rich pasturage is ordinarily scarce in that part of the State.

(7) Velvet beans have not been very successful in plantings made at the test farms in Iredell and Buncombe counties. The plants made relatively small growth and failed to mature.

In Wake County and eastward, the varieties class as follows, in the order given, in amount of growth per acre: Florida Velvet, One Hundred Day Speckle, Chinese, Wakula, and Yokohama.

For seed production in the eastern portion of the State the varieties would stand as follows: One Hundred Day Speckle, Wakula, Yokohama, Chinese, and Florida Velvet.

The Florida Velvet does not ordinarily mature at Raleigh, and only about 10 per cent of the seed of the Chinese have matured here in the past.

At present, for North Carolina conditions generally, the One Hundred Day Speckle variety, because of its earliness, is considered the safest and best variety for general use.

Respectfully submitted,

C. B. WILLIAMS,
Chief, Division of Agronomy.

REPORT OF THE DIVISION OF CHEMISTRY.

To the Director:

The two principal lines of work of the Division relate to cotton-seed meal and soil bacteriology. The first line of work has been carried on, to some extent, in coöperation with the Division of Animal Industry; and the second, to some extent, with the Divisions of Bacteriology and Agronomy.

COTTON-SEED MEAL WORK.

The results of our investigations have shown that cotton seed contains a principle which is actively toxic to the classes of animals which have been under experiment. The various classes used were rabbits, guinea pigs, fowl, and swine. The toxic principle was identified as gossypol, a substance first isolated by Marchlewski in 1899. Some of its chemical, but none of its physiological, properties were described by him.

Since the publication of our article three valuable contributions by other investigators have appeared, the authors being C. A. Wells of the Georgia Experiment Station, Rommel and Vedder of the Bureau of Animal Industry of the United States Department of Agriculture, and Misses Richardson and Green of the University of Texas.

Studies of cottonseed meal from a nutritional standpoint are in progress by Osborne and Mendel of the Connecticut Experiment Station and by McCollom and his associates of the Wisconsin Experiment Station.

Wells, after making exhaustive experiments to test the acidosis theory of cotton-seed poisoning has abandoned it.

Rommel and Vedder have offered as an explanation of the ill effects usually accompanying its feeding to swine that cotton-seed meal contains no active toxic principle, but that it lacks "vitamines," and that the resulting disease is similar to if not identical with "beriberi" which is often produced in human beings from eating highly milled food products. Their paper being preliminary contained only a few experiments.

Misses Richardson and Green, using albino rats, have also concluded that cottonseed meal is not actively toxic; contains efficient protein, but is deficient in minerals.

Without denying the deficiencies of cottonseed meal, it cannot be admitted that these are the chief causes of the harmful results from feeding it, as it has been found that cotton-seed kernels are not lethal to pigs after gossypol has been extracted.

During the past year further experiments with rabbits was carried on, using many more swine than were used during the experiment of the previous years, and some experiments were instituted also with albino rats.

The rats show a very high resistant power toward cottonseed meal, but are very quickly affected by unpressed cotton seed. They appear to

live indefinitely upon a diet of cotton-seed flour, which, however, is quickly toxic to rabbits.

These more or less conflicting views as to the toxicity of cotton-seed meal may be explained partly on the peculiarities of different classes of animals used for experiment and partly by the possibility of variation in the toxicity of different cotton-seed meals. The fact that rats are promptly affected by crushed kernels, but can live over long periods upon cotton-seed meal as the sole source of protein, carbohydrates and minerals, indicates that the process of manufacture is a fairly efficient means of removing the toxic principle. It is possible that a close study of the conditions of meal manufacture may show how this principle may be more efficiently eliminated. This is an important matter for future investigation.

Some attention has been given to the study of effect of aging upon the toxicity of a meal, and it is hoped to take up the plan proposed some time ago of studying the distribution of gossypol in the different parts of the cotton plant and in different varieties of the plant grown under different climatic conditions.

The experiments during the year have confirmed the views previously presented that gossypol is the toxic substance of cotton seed. A paper embodying these results is now in preparation for publication.

SOIL BACTERIOLOGY.

Studies in nitrification have been continued during the year and have been mainly with solutions. An effort is being made to study the most desirable concentration of the various constituents, the most satisfactory form of container, optimum time and temperature of incubation, and the other changes in nitrogen combination accompanying ammonification and nitrification.

PAPERS AND PUBLICATIONS.

The following papers have been published or presented at the meetings of various societies during the year:

Feeding Experiments with Cotton-seed Products, by W. A. Withers and F. E. Carruth before the N. C. Section of the American Chemical Society.

Chemistry of Gossypol, by F. E. Carruth before the N. C. Section of the American Chemical Society.

Cottonseed Meal as a Feeding Stuff, by W. A. Withers before the N. C. Cotton-seed Crushers Association.

Properties of Substantive Cotton Dyes, by F. E. Carruth before the N. C. Section of the American Chemical Society.

Gossypol the Toxic Substance in Cottonseed Meal, by W. A. Withers and F. E. Carruth in the *Journal of Agricultural Research*, November 15, 1915.

Respectfully submitted,

W. A. WITHERS,
Chemist.

REPORT OF THE ANIMAL INDUSTRY DIVISION.

To the Director:

I herewith submit the annual report of the Investigational work conducted by the Animal Industry Division of the Experiment Station.

The following statements give a brief summary of the projects which are being conducted:

SWINE.

1. To determine the toxic principles in cottonseed meal.

2. To determine the value of temporary pasture crops for fattening hogs.

3. To determine the value of waste peanuts, soybean meal, and peanut meal as feeds for hogs.

4. To determine the effect of peanuts, soybeans, mast, soybean meal, peanut meal and other feeds upon the bodies of hogs and their lards, with a view to developing a plan of feeding to counteract any unfavorable results.

5. To determine the expense of raising pigs to the weaning age in the various parts of the State.

BEEF CATTLE.

1. To determine the relative value of various quantities of cotton-seed meal for fattening steers in connection with cotton-seed hulls and corn silage, and note the effect of these feeds upon the quality of the meat.

2. To make a direct comparison of the relative value of cotton-seed hulls and corn silage when fed in conjunction with cottonseed meal.

3. To determine the effect of varying amounts of cottonseed meal upon the health, development, and breeding qualities of young calves.

4. To determine the cause, if possible, of the disease commonly called Trembles.

5. Coöperative beef cattle work with the Bureau of Animal Industry, Washington, D. C., conducted on the farm of Mr. T. L. Gwyn, of Haywood County. These experiments were inaugurated November 1, 1913. Since that time the following projects have been studied:

(*a*) To determine the profit, if any, in introducing corn into a ration of cottonseed meal.

(*b*) To determine the best and most economical method of wintering stockers when they are to be finishing the following summer on pasture.

(*c*) To determine the feasibility and practicability of fattening cattle in the summer on pasture when the pasture is supplemented with cotton-seed meal.

6. To determine the value of peanut meal as a fattening ration for beef cattle.

SHEEP.

1. To determine the cost of maintaining a flock of sheep.
2. To determine the cost and feasibility of producing early lambs for the April, May, and June markets.
3. To determine the effect of cotton-seed meal rations when fed in various quantities upon the health, condition, and reproductive systems.
4. To determine the value of the use of Merino, Shropshire, and Barbado rams in grading up native ewes and crossing upon each other.
5. To determine whether the Barbado sheep are in any degree resistent to the attacks of stomach worms.
6. To determine the influence of various kinds and amounts of grain in overcoming the ravages of stomach worms in lambs during the summer months.

DAIRY CATTLE.

1. To determine the cost of raising calves in the South.
2. To determine the value of silage in a milking ration when compared with Southern dry feeds.
3. To determine the value of silage as compared with winter and spring pastures.
4. To determine the value of various winter feeds for wintering dairy calves, special emphasis being given to cottonseed meal.
5. To determine the best and most satisfactory method of making skim milk, buttermilk, and cottage cheese.
6. To determine, if possible, a practical method of eliminating onion flavor from milk and butter.

HORSES AND MULES.

1. To determine the place of cotton-seed meal in a ration for working horses and mules.

POULTRY.

1. To determine if cottonseed meal can be safely fed to fowls, and if so, the limit of safety.
2. To study Mendelian characters (in egg production) in Leghorn breeding.
3. To determine best feeds and methods of fattening fowls.
4. To determine best methods of preparing fowls for shipment to curtail shrinkage.
5. To determine best methods of rearing turkeys to combat blackhead.
6. To study Mendelian traits (in color study of egg) in Barred Plymouth Rock breeding.
7. Egg and poultry shipping experiments and market studies.
8. To determine the exact amount of excreta voided by fowls in 365 days.

9. A study of parasitic conditions of the State. To determine the best methods of combating the same.

10. A study of tumors of the fowl.

11. A study of abdominal purulent conditions of the hen.

12. To determine the best methods of housing and caring for fowls in North Carolina.

13. To determine the best methods of housing the sitting hen and the hen with her brood.

14. To work out profitable simple rations for the farm brood and the farm flock.

15. To determine the effects of dry lot handling of the flock.

16. To determine the value of free range and degree of protection of the farm crop by fowls.

17. To determine the cost of baby chicks hatched by artificial *versus* natural means.

18. To determine the cost of brooding chicks, natural *versus* artificial means.

19. Studies in the anatomy and histology of the fowl.

20. Study in therapeutics of the fowl.

21. To determine if mineral feeding will stimulate growth and development.

SWINE.

The swine work which is being conducted at the Central Farm at Raleigh, at the Iredell Branch Station, at the Edgecombe Branch Station, and at the Pender Branch Station has developed very satisfactorily during the last twelve months. On account of lack of funds the work has been handicapped, but as more funds become available for the test farms it is hoped that the work can be done more completely and comprehensively than at present as well as inaugurate new and additional work upon the Buncombe and Wenona Branch Stations.

Soybean Pastures for Fattening Hogs.

(Edgecombe Branch Station.)

One of the greatest lessons that the farmers of the State need to learn is that money is usually lost—or at least a sufficient amount is not made—when hogs are fed in dry lots without pasture of some kind. One of the big problems of the authorities of the Animal Industry Division is to determine the value of some of our various hog grazing crops and to carry this information to the farmers who are to use our results. Farmers all over the State are becoming very greatly interested in soybean pasture, and are calling upon us for accurate information as to just how reliable this pasture is and how it should be used. Last fall (October 29-December 28) a test was made at the Edgecombe Branch Station to determine the value of five acres of soybean pasture. The crop was probably far below the average. The beans were planted in

rows and cultivated. As they were planted late they were not ready for grazing until October 28th, when 18 pigs weighing 87 pounds each were turned on to the five acres. In addition to the pasture, the pigs were given a fourth ration of nine-tenths corn plus one-tenth tankage. As a check lot, three other pigs were placed in a small bare lot and fed a full ration of nine-tenths corn plus one-tenth tankage. The five acres of soybeans afforded feed for 18 pigs for sixty days. The pigs in both lots made good gains during this time. The pigs in the bare lot making an average daily gain of 1.28 pounds, while those in the pasture lot made an average daily gain of 1.38 pounds. The cost, however, to make these gains was decidedly in favor of the pasture, when pasture is charged against the gains at $10 an acre, corn at $1 a bushel, and tankage at $2.60 per hundredweight. The hogs in the bare lot made unusually economical gains, as their gains cost only $5.60 per hundredweight. The hogs in the soybean pasture lot gained at the rate of $4.96 per hundredweight. When hogs were valued at 8 cents a pound on foot, each acre of grazed soybeans proved to be worth $19.25. The yield of seed was not obtained in this particular experiment, but the hogs gave decidedly larger returns per acre than the seed themselves would have realized. When it is remembered that the crop was not a normal one, the results secured were entirely satisfactory.

Peanut Against Soybean Pasture as Feeds for Hogs.

(Pender Branch Station.)

A second crop which the farmers of North Carolina are coming very rapidly to appreciate is peanuts. They appreciate this both as a commercial feed and as a feed for hogs. The Animal Industry Division has already done considerable work to determine the exact value of peanuts for hogs, and these results have been presented in my former reports. Farmers, however, are continuously asking us the relative value of peanut and soybean pastures. To be able to answer these questions concisely an experiment has been outlined at the Pender Branch Station. One year's results have been secured. The second year's experiment is now under way. To determine the relative value of these two crops 1.65 acres of soybeans and 1.72 acres of peanuts were planted the spring of 1915. Both crops were planted in rows and cultivated, and were ready to graze September 16. Nine pigs, which averaged 112 pounds in weight, were turned into each field and given a half ration of corn in addition to the pastures. The above area of soybeans afforded feed for the nine pigs for sixty-one days, but an equivalent area of peanuts afforded grazing only thirty-six days. The length of time grazed, however, does not determine the relative value of the two crops as the pigs upon the peanuts gained very much more rapidly than did those upon soybeans. The soybean-fed pigs gained at an average daily rate of .98 of a pound, while the peanut-fed pigs gained at an average daily rate of 1.36 pounds. When corn is valued at $1 a bushel and the pasture

at $10 an acre, it cost $5.20 to make each 100 pounds of increase in weight in the soybean lot and $5.41 in the peanut lot. The pounds of seed produced on these areas were not determined, but after the cost of the grain was deducted it was learned that each acre of soybeans produced $18.80 worth of pork, while each acre of peanuts produced $16.61 worth of pork, the hogs being valued at 8 cents a pound on foot.

Feeding Value of Damaged Peanuts and Peanut Meal When Fed to Hogs.

(Edgecombe Branch Station.)

The eastern part of the State very frequently suffers very great losses on account of the crop of peanuts being damaged in the shock. The Animal Industry Division has had many inquiries relative to the value of damaged peanuts when fed to hogs. Last year a series of tests was inaugurated upon the Edgecombe Branch Station to thoroughly test the problem. The first experiment was presented in my last report. I am presenting the second one now.

In connection with this study we have been called upon to determine the value of peanut meal as farmers are continuously asking the relative value of wheat shorts, damaged peanuts, peanut meal, and soybean meal. In the particular experiment reported here corn is valued at $1 a bushel, wheat shorts and peanut meal each cost us $30 a ton, peanut meal being purchased at a local mill; the damaged peanuts are valued at 75 cents a bushel, although many farmers place no value at all upon them. Thirty Berkshire pigs raised upon the Edgecombe Branch Station were used in the test. At the beginning (January 25, 1916) they averaged about 98 pounds in weight. At the close of the test (June 22, 1916) they averaged from 200 to 218 pounds in weight, depending upon the lot in which they were fed. It is interesting to note in passing that these pigs were shipped to the Baltimore market and sold for $10.35 per hundredweight. The pigs in the first lot were fed a ration of two-thirds corn plus one-third shorts; those in the second lot a ration of two-thirds corn and one-third damaged peanuts; those in the third lot a ration of two-thirds corn and one-third peanut meal. For a long time experiment of this character (149 days) the pigs all made reasonably satisfactory gains, as those in the first lot made an average daily gain of .69 of a pound, those in the damaged-peanut lot .71 of a pound, and those in the peanut-meal lot .81 of a pound. In the wheat-shorts lot it cost $10.35 to make each hundred pounds of increase in weight, in the damaged-peanut lot $9.83, and in the peanut-meal lot $8.81. When waste peanuts, therefore, have a fictitious value of 75 cents a bushel, peanut meal is the cheaper food. It is interesting to note, however, in this connection that waste peanuts were sold by means of hogs for more than 75 cents

a bushel. Wheat shorts proved to be the most expensive supplement. This test has been given the public by means of circular-letters and the press and has attracted considerable attention.

Wheat Shorts, Peanut Meal, and Soybean Meal as Feed for Hogs.

(Central Branch Station.)

This experiment was outlined primarily to determine the effect of soybean meal and peanut meal upon the bodies of hogs. Some packing plants and other consumers claim that both of these materials produce just as undesirable a body as do soybeans and peanuts. This phase of the work, however, is presented in another part of this report. Incidentally, some interesting results were secured as to the relative value of wheat shorts, soybean meal, and peanut meal when fed in conjunction with corn. For the sake of the first part of the experiment, the hogs were kept in very small lots, the floors of which were covered with cement. On this account the gains were, of course, not satisfactory, but the results are comparable. The pigs in the first lot were fed a ration of two-thirds corn plus one-third wheat shorts, the second lot of pigs was fed a ration of two-thirds corn plus one-third soybean meal, the third lot of pigs was fed a ration of two-thirds corn plus one-third peanut meal. At the beginning of the experiment (January 24, 1915) the pigs were small, averaging about 43 pounds in weight; in fact, they were small 140 days later, when the experiment closed, as they did not make rapid gains. The pigs in the wheat-shorts lot made an average daily gain of .29 of a pound, those in the soybean-meal lot .44 of a pound, and those in the peanut-meal lot .37 of a pound. The cost to make gains was extremely high, as it cost $19.80 to make each hundred pounds of increase in the shorts lot, $11.79 in the soybean lot, and $14.56 in the peanut-meal lot. Corn was valued at $1 a bushel, soybean meal at $40 a ton, and peanut meal at $30 a ton.

Feeding Cottonseed Meal to Hogs.

The cottonseed meal work is being carried on in coöperation with the Chemistry Division. This work, on account of being extremely painstaking and expensive, is carried on at the Central Branch Station at Raleigh. This character of work necessarily means that the gains are to be expensive and heavy losses are to be encountered. Last year I reported that progress was being made upon this study, and that we felt that we would finally get results which would be of value to both the cotton and hog producers of the South. We have gone far enough to know that copperas and iron both overcome in a measure the danger when cottonseed meal is fed to hogs. We cannot say, however, that these two chemicals eliminate the danger completely. During the past winter five lots of hogs were used in this particular experiment, which began November 29, 1915, and closed 126 days later, on April 3, 1916.

The first lot of hogs was fed a ration made up of seven-eighths corn plus one-eighth cotton-seed meal, the second lot was fed a ration of seven-eighths corn plus one-eighth cottonseed meal plus a solution of iron sulphate, the third lot was fed a ration made up of seven-eighths corn plus one-eighth cotton-seed meal plus a solution of citrate of iron and ammonia, the fourth lot of hogs was fed a ration of four-eighths corn plus three-eighths wheat bran plus one-eighth cotton-seed meal, the fifth lot of hogs was fed a ration of seven-eighths corn plus one-eighth peanut meal. At the beginning of the test the pigs averaged about 50 pounds in weight. As the object of this experiment was not primarily to make rapid or economical gains, but to try out the effect of various combinations of cotton-seed meal and chemical solutions upon the health of swine, the pigs were placed in small pens covered by board floors. They were handled in this way to preclude the possibility of securing any food except that given them. The pigs were in the test for a long period of time (126 days), but attention should be called to the fact that the proportion of cotton-seed meal was small. One pig in the first lot died December 1st, but this was certainly not due to cotton-seed meal as the experiment was inaugurated November 29. Two pigs died in the second lot—the lot in which the solution of iron sulphate was used—one on February 9th, or 72 days after the inauguration of the experiment, and the other on March 31st, or 123 days after the experiment began. No other deaths were secured. It is interesting to note, however, that the gains were more satisfactory where the iron sulphate was used. The pigs in the first lot, where simply corn and cotton-seed meal were employed, made an average daily gain of .25 of a pound per pig per day; those in the second lot, where the iron solution was used, gained .35 of a pound per pig per day; those in the third lot, where the citrate of iron and ammonia solution was employed, gained .42 of a pound per pig per day; those in the fourth lot, where both wheat bran and cotton-seed meal were employed, gained .30 of a pound per pig per day; and those in the fifth lot, where peanut meal was employed, gained .32 of a pound per pig per day. All of the rations, therefore, were more effective than plain cotton-seed meal.

This is a line of experimentation which should be carried to a final conclusion no matter what the cost may finally be.

Expense to Raise Pigs to Weaning Age.

No problem connected with swine production is of more importance than those problems associated with the suckling pig. On account of its importance we are studying various methods of raising pigs to the weaning period at the Central Branch Station and upon three of the branch stations. Reliable information is being collected as we have gone far enough now to get some definite results. Notwithstanding the fact that this period is probably the most expensive period of the pig's life no experiment stations have made careful studies to determine the cost

and work out the best methods of feeding. When this work has been under way a number of years we will have records that will be worth much to the farmers of the State. At the present time exact records are being kept of about 35 sows and their litters. In a report of this kind I can speak of averages only. At the Edgecombe Branch Station the sows averaged 5 1/11 pigs raised to weaning age. This, of course, does not represent the number farrowed. When weaned at eight weeks of age the pigs averaged 24.3 pounds in weight. When the cost of feed as well as cost of labor is charged against the pigs, it is found that the pigs upon the Edgecombe Branch Station at weaning time cost $1.94. At the Pender Branch Station the sows have averaged raising 6¼ pigs to weaning time. The pigs upon upon this farm were weaned at 8 weeks and averaged 28.8 pounds in weight and each pig has cost us $3.34. At the Iredell Branch Station the sows have averaged raising 6⅙ pigs to the weaning time. These pigs have averaged 31.8 pounds in weight and have cost $2.24 each.

The Cheapening Effect of Peanuts, Soybeans, and Mast Upon the Bodies of Hogs.

Farmers of the State who live in sections where mast, peanuts, and soybeans are grown thoroughly appreciate the fact that these feeds, as well as others, produce a body which is objectionable to the packer and to the consumer. Those of us who have tried it know that packers in the first place do not want hogs at all which have been fed upon softening feeds. Some packers will buy them, but when they do they deduct from 1 to 2 cents a pound. This means from $2 to $5 a head. This represents an enormous total loss to the State and discourages many farmers from using some of the very best Southern feeds we have. There is no doubt at all, I believe, that a way can be found to overcome this cheapening effect. As this is one of the most important problems in the South, we are devoting considerable time to its solution. Practically all of the hogs involved in the experimental work reported above are used in this scientific phase of our work; that is, these hogs are butchered, samples of fat taken and sent to out-laboratories at Raleigh, where they are carefully analyzed. While we have been slow in getting these studies under way, still we have made very material progress. I devote much of my personal attention to this problem and Mr. McCarty has devoted most of his time to the chemical phases. During the last twelve months several hundred samples from hogs which have been fed upon various combinations of feeds such as peanuts and soybeans have been analyzed. In all of this work corn-fed hogs are taken as a basis, this being done because it is recognized practically the world over that the bodies of hogs which have been fattened upon corn alone are satisfactory to the packer and ultimate consumer. The bodies of hogs which have been fattened upon corn alone are satisfactory because the lard is firm, white, and fine in texture as well as the body. We have learned

that the average melting point of lards made from the kidney fat of hogs fattened upon corn alone is approximately 43 degrees. In every feed or combination of feeds which produces leaf lard that melts at 43 degrees or above is considered satisfactory.

This investigational work has been done, as stated above, upon the Central Branch Station, the Edgecombe Branch Station, the Pender Branch Station and in coöperation with Messrs. Holderness and Shook at Tarboro. Recently a comprehensive experiment was carried on in coöperation with Messrs. Holderness and Shook. Following the custom of the average farmer who lives in the peanut section, a lot of hogs was permitted to graze upon waste peanuts. In this particular test the peanuts lasted 82 days, when the hogs were brought into the barn lots. At the end of the peanut period the bodies of the hogs were, of course, exceedingly soft as they had been fed upon peanuts exclusively. If they had been sold at this time the markets would have discriminated against them to the extent of from 1½ to 2 cents a pound. When the hogs arrived at the barnyard they were divided into ten lots, 20 hogs being placed in each lot. To determine the best and most economical rations for finishing and hardening the bodies of these hogs, the lots of hogs were fed upon corn alone and corn in conjunction with various amounts of cotton-seed meal. The finishing or hardening period continued twenty-six days, when the animals were shipped to the Richmond market. The following table gives a summary of the work:

Lot	*Hardening Ration*	*Days on Hardening Ration*	*Melting Point*
1	Corn alone	26	37.6 degrees
2	Shelled corn 9-10 Cotton-seed meal 1-10	26	39.6
3	Shelled corn 7-8 Cotton-seed meal 1-8	26	39.2
4	Shelled corn 4-5 Cotton-seed meal 1-5	26	38.3
5	Shelled corn 2-3 Cotton-seed meal 1-3	26	39.3
6	Shelled corn 1-2 Cotton-seed meal 1-2	26	36.9
7	Cracked corn 2-3 Cotton-seed meal 1-3	26	39.5
8	Cracked corn 3-4 Cotton-seed meal 1-4	26	38.7
9	Ear corn 2-3 Cotton-seed meal 1-3	26	38.0
10	Shelled corn 9-10 Cotton-seed meal 1-10	26	38.0

It is seen from this table that the soft-bodied hogs were not fed upon hardening feeds a sufficient length of time to bring them back to the

corn standard; in fact, none of these lots had an average melting point as high as 40 degrees, while the average melting point for corn-fed hogs is approximately 43 degrees. The packers who purchased these hogs deducted one-half a cent a pound on account of the softness, and claimed that they deserved an even greater deduction in price. The above work clearly shows that hogs which have been fed upon peanuts alone for long periods of time must be finished in dry lots upon concentrated feeds for more than twenty-six days before the bodies are brought back to a corn standard. This need not discourage the farmer as he can well afford to feed them a while longer.

This problem has also been studied at the Pender Branch Station and Edgecombe Branch Station. Recently a test was carried through at the Pender Branch Station to study the effectiveness of corn alone as a finishing ration after the bodies of hogs had been rendered soft as a result of grazing peanut and soybean pastures. The pigs in Lot 1 were grazed upon soybean pasture for sixty-one days, and during this time received a partial ration of corn. At the end of the soybean period the melting point of the leaf lard taken from the two hogs which were slaughtered was 37 degrees. The remaining pigs were enclosed in a lot and fed for forty-one days upon corn alone. When these hogs were slaughtered and the melting point of the lard determined it was found to be 39.8 degrees. The pigs in Lot 2 ate peanut pasture and a partial ration of corn for thirty-six days and at the end of this time had an average melting point of 33.4 degrees. Their bodies were exceedingly soft. The remaining pigs in Lot 2 were enclosed in a small lot and finished upon corn alone for sixty-six days, and the melting point of the lard was raised to 37.2 degrees.

At the Edgecombe Branch Station a recent test was made to study the effect of a ration made up of corn nine-tenths plus tankage one-tenth and the same ration when supplemented by soybean pasture. The two lots of pigs were fed for sixty days. The pigs in the dry lot had an average melting point of 43.3 degrees, while those which had the ration of soybean pasture had an average melting point of 33.3 degrees. The remaining pigs in the soybean lot were placed in dry lots for finishing, and the period continued for twenty-one days. These pigs, which were finished upon corn and tankage, had an average melting point of 35.6 degrees, while the lards taken from those which were finished upon corn and cotton-seed meal had an average melting point of 38.5 degrees. The bodies of the hogs, however, were all too soft.

In some recent work done in coöperation with Messrs. Holderness and Shook and upon the branch stations, it has been found that exceedingly soft-bodied hogs can be brought back to normal between thirty-two and forty-nine days when corn is used in conjunction with cotton-seed meal. We feel that we are making satisfactory progress with this problem.

Packers are also claiming that soybean meal and peanut meal produce soft-bodied hogs. We are studying this problem carefully, and so far we

have found very little evidence to warrant us in saying that these two meals have a tendency to produce soft-bodied hogs. These problems, however, are to be studied more carefully and thoroughly as we go along.

BEEF CATTLE.

The beef cattle work, both investigational and field, has been going along in a satisfactory manner. Messrs. Curtis, Jerdan, and Case are putting in all of their time in this kind of work. Mr. Hostetler is devoting part of his time to investigational phases.

Best Feed for Wintering Stock Cattle.

Last winter 67 head of grade cattle were wintered on the Experiment Station Farm to determine the best methods of wintering stock cattle. In this test varying amounts of corn silage and cotton-seed meal were used. The steers in Lot 1 were fed an average daily ration of 20 pounds of corn silage plus 1 pound of cotton-seed meal, those in Lot 2 an average daily ration of 23 pounds of corn silage, those in Lot 3 an average daily ration of 20 pounds of corn silage, those in Lot 4 an average daily ration of 20 pounds of corn silage plus one-half pound of cotton-seed meal. During the last forty-four days of the experiment all the steers received 5 pounds of corn stover per day in addition to the above rations. The steers all lost in weight, those in the first lot losing during the 148-day winter period 16.2 pounds, those in the second lot 52.9 pounds, those in the third lot 72.2 pounds, and those in the fourth lot 69.4 pounds. At the prevailing prices of cotton-seed meal and corn silage, it cost $10.29 to winter each steer in the first lot, $8.18 in the second lot, $7.23 in the third lot, and $8.09 in the fourth.

This test shows that cotton-seed meal and corn silage afford an excellent combination for the winter maintenance of beef cattle. These cattle were sold in Virginia, and the work is planned with the idea of following the cattle through the summer to get the results of pasture. Part of this information is being collected, but of course cannot be reported at this early date.

Best Rations for Wintering Stock Cattle.

(Iredell Branch Station.)

Last winter a car-load of grade Shorthorn cattle were shipped to the Iredell Branch Station for some additional investigational work on the question of wintering stock cattle. The cattle shipped to that station were divided into two lots, the first lot being fed upon an average daily ration of 20 pounds of corn silage plus 1 pound of cotton-seed meal and the second lot upon 20 pounds of corn silage alone. The steers in the first lot were made to gain somewhat in weight during the winter period of 160 days, each steer gaining 24 pounds. The steers in the second lot,

where no cotton-seed meal was employed, lost in weight, as each steer suffered a loss of 55 pounds. It cost, of course, considerably more to winter the cattle in the lot where cotton-seed meal was used, as each steer in this lot entailed an expense of $9.14, while each steer in the second lot was gotten through with only an expenditure of $6.11. The steers in the first lot were, of course, in very much better condition when spring arrived, but it is a question as to whether this really makes any difference upon the arrival of the subsequent fall. This question, however, is to be studied further.

Best Feeds for Wintering Beef Calves.

(Edgecombe Branch Station.)

During the past winter an experiment was also carried on at the Edgecombe Branch Station to determine the most profitable method of wintering beef calves, using cotton-seed meal and corn silage as a ration, the object being to determine if cotton-seed meal could be fed profitably. The calves in Lot 1 were each fed 15 pounds of corn silage plus 1 pound of cotton-seed meal, while those in Lot 2 were fed 15 pounds of corn silage per head per day. At the beginning of the test the calves in the first lot averaged 340 pounds in weight, while those in the second lot averaged 321 pounds in weight. During the winter period of ninety-eight days each calf in the first lot made an average daily gain of 19 pounds, while each calf in the second lot lost 16 pounds. When silage is valued at $4 a ton and cotton-seed meal at $40 a ton, it cost $4.90 to feed each calf in the first lot the ninety-eight days, and $2.94 to feed each calf in the second lot the same length of time. This small amount of cotton-seed meal did not, of course, injure the calves in any way; they came through in perfect health and were in much better shape for grazing than were those in the second lot.

Raising Young Calves on Cotton-seed Meal.

(Central Station Farm.)

There is probably no one live-stock problem about which we are questioned so much as the one relating to the feeding of cotton-seed meal to young animals of all kinds. The farmers of our State, of course, desire to use cotton-seed meal just as extensively and continuously as possible. Many of them, however, have found that with young animals especially it is dangerous when used too lavishly, and the calls all hinge around the point as to just how much can be used with entire safety. In our swine work we have found that cotton-seed meal has a definite poison—gossypol. This poison kills swine readily and just as readily injures other animals, especially when fed to them when young. For these reasons Mr. Curtis and Mr. Eaton have been working together to determine, if possible, the relative amounts of cotton-seed meal products that may be fed to growing calves under varying conditions, with especial refer-

ence to the kind of roughage used and antidotes. Last winter 20 grade Jersey calves weighing from 150 to 450 pounds were employed in this experiment. Each calf in Lot 1 was given 1 pound of cotton-seed meal for each 100 pounds of live weight and cotton-seed hulls; each calf in Lot 2 was given 1 pound per 100 pounds live weight of a grain mixture composed of equal parts of cracked corn and cotton-seed meal with cotton-seed hulls; each calf in Lot 3 received 1 pound of cotton-seed meal per 100 pounds of live weight and a mixture of beet pulp and cotton-seed hulls; each calf in Lot 4 received the same feed as the calves in Lot 1, except that for each pound of cotton-seed meal that was fed a quart of iron sulphate solution was added and stirred with the feed. This particular experiment closed May 1st as one of the calves in the third lot died on April 12th as a result of cotton-seed meal poisoning and several of the other calves were losing their sight. The calves in lots 2, 3, and 4 were then turned on pasture and weighed again on October 31st. All of them showed subsequent gains for the summer, and their eyes had apparently entirely recovered from the trouble. This point is of particular interest to farmers who have experienced this same sort of trouble.

A similar experiment was repeated during the last winter and summer, but with practically the same results. It is planned to carry the calves which do not die as the result of using the cotton-seed meal to the breeding age. The charge is commonly made against cotton-seed meal that its constant use produces sterility and abortion. When this part of the test is brought to a close data bearing upon these two charges will be available.

Maintaining Stock Cattle Through the Winter Months with a View to Finishing on Pasture the Subsequent Summer.

(Gwyn Experimental Farm, Haywood County.)

This beef cattle work is being conducted in coöperation with Mr. T. L. Gwyn, of Haywood County. No part of our work is appealing more to the farmer any more than this. The farmers who live in the mountains and under conditions similar to Mr. Gwyn's are watching this investigational work very closely.

During the last winter 114 stockers were involved in this experiment. The 114 stockers were divided into five lots, the first lot being fed upon an average daily ration of 3.15 pounds of ear corn and 11.4 pounds of a mixture of corn stover, hay, and straw; each steer in lots 2 and 3 was fed a daily ration of 18 pounds of corn silage and 6 pounds of the roughage mixture; each steer in Lot 4 was grazed through the winter without the addition of any grain or hay; the animals in Lot 5 were really calves and were fed upon a ration of ½ pound shelled corn plus ½ pound cotton-seed cake. At the beginning of the test the stockers varied, of course, somewhat in weight, but averaged from 762 pounds to 813

pounds per lot. The calves averaged 270 pounds in weight. The stockers in the first three lots lost in weight 34, 41, and 40 pounds, respectively. The stockers in the fourth lot (this is the lot which was grazed upon winter pasture alone) gained 26 pounds each. The calves gained 9 pounds each. The experiment lasted 119 days. Counting pasture at $1 a month per animal and the other feeds at local prices, it cost $12.14 to winter each steer in the first lot, $7 in lots 2 and 3, $5.30 in the winter pasture lot, and $4.18 to feed each one of the calves during the winter period of 119 days. When April 13th came the winter work was brought to a close and the cattle were placed upon summer pasture. They were carried on pasture until August 31st, when they were sold. Lots 2, 3, and 4 and 5 were carried through on pasture alone during the pasture season. Lot 1 was given an average daily ration of 4 pounds of cotton-seed cake in addition to the pasture. All the steers through the pasture season made good gains, but we did not find that those which were fed cake in addition to pasture made very much more rapid gains than those which had pasture alone. The steers which were not fed cotton-seed cake were sold at the farm for $7.25 per hundredweight. The steers in the first lot which ate cotton-seed cake in addition to the pasture were sold in Baltimore at $8.25 per hundredweight. When the total cost of shipping and feed, including pasture at $5 for the five winter months, were charged against the operations, it was found it did not pay to feed the cotton-seed cake. The steers in lots 2, 3, and 4, which ran upon pasture alone, yielded a net profit of $21.63, $20.94, and $24.02, respectively, while the steers in Lot 1, where cotton-seed cake was employed, yielded a net profit of only $13.01 each. The farmers in the mountains are particularly interested in the wintering pasture proposition as this pasture consisted of native pastures of the territory which have been allowed to grow up in the summertime without grazing and fall over for winter use. This kind of pasture has proven to be the cheapest winter feed we have found.

SHEEP.

The experimental work with sheep has been going along in a satisfactory manner, although many projects are not being studied at the present time.

Experimental Work with Breeding Ewes.

This breeding work is of such a nature that it is difficult to show the results in tabular form. This work was outlined about two years ago for the purpose of determining the effect, first, of cotton-seed meal on the health and reproductive organs of breeding ewes, and, second, to determine the possibility of incorporating Barbado blood with Shropshire and Merino blood in producing an early breeding ewe and preventing the ravages of stomach worms. Up to the present time no detrimental effects have been discovered from feeding breeding ewes a ration of two-thirds cotton-seed meal and one-third cracked corn. It seems that

sheep are particularly resistant to the poisonous effects of cotton-seed meal. This study, however, is being continued and will be reported probably next year.

It is not possible to report the results of crossing the Barbado with the Shropshire and Merino blood at the present time. The cross-bred animals are just being bred this summer. It is interesting to note, however, that the wool from the cross-bred animals was sold on the market for the same price as the wool from the other ewes. It has often been claimed that the Barbado is resistant, or partly resistant, to the ravages of the stomach worm. In our investigational work here we have not found this to be true.

Feeding Lambs in the Summer to Prevent Stomach Worms.

The greatest drawback to sheep production in the South is the Stomach Worm. The lamb's first summer is the critical period of its life. The majority of farmers recognize this. Where it is possible to do so, the best method of combating the stomach worm is, of course, to change the lamb to new and uninfested pastures, but where it is not possible to do this other methods must be resorted to.

During the past summer an experiment was carried on at Raleigh to determine if feeding a heavy grain ration would have any effect in overcoming the ravages of the stomach worm. Thirty lambs, divided into three lots, were used. All of the lambs were grazed upon good Bermuda pasture during the entire summer period. As the pasture had been grazed previously by sheep it was assumed that it was badly infested. The lambs in the first lot received nothing but the pasture; each lamb in the second lot received one-half pound of grain per day; each lamb in the third lot received 1 pound of grain per day. The experiment closed October 30, 1916, and during the summer nine lambs died out of the first lot, eight lambs in the second lot, and four lambs in the third lot. Our records show that at least two of the lambs in the third lot did not die from stomach worms. Lightning killed two. The results, therefore, of the first year's work indicate strongly that there is a very definite relationship between deaths by stomach worms and grain fed through the pasture season.

Best Rations for Feeding Breeding Ewes During the Winter Months.

In the fall of 1915 twenty grade breeding ewes were placed at the Iredell Branch Station. When cold weather arrived they were divided into two lots, one lot being kept in a shed or corral during the wintertime. This lot was fed corn silage and a mixture of one-half cracked corn, one-fourth cotton-seed meal, and one-fourth wheat bran. The other lot was kept in a pasture during the daytime. The pasture was a meadow from which hay had been cut. When spring arrived the sheep which were kept in a pasture had gained 20 pounds in weight, and the

cost was only about half that of the barn-fed ewes. The barn-fed ewes only gained about 5 pounds in weight. In the spring the sheep were all sheared, the wool selling for 36 cents per pound, or $2.99 per ewe. This amount is practically sufficient to keep the ewes during the year when good pasture is available.

Milk Sickness.

There is no particular reason why a study of this test should be discussed under the head of sheep, except that we are using some of our old ewes at the Central Branch Station in this work. Most of the complaints which come to us relative to milk sickness have reference to cattle, but our study can be made very much more economically by using our old discarded ewes. This work was begun early in the spring. Our offices get very many inquiries from the mountains about this mysterious sickness. Mr. Curtis and Dr. Wolf began the study by shipping various weeds to Raleigh and feeding them to ewes. The ewes which were selected grew in the neighborhood of places which were pointed out as being spots liable to cause the sickness. We have found out definitely that at least one weed produced typical milk sickness. This is what is known as Rich weed. We have been shipping this weed to Raleigh at regular intervals all through the summer and feeding it to ewes. No difficulty has been experienced in producing the typical symptoms which are usually described by the farmers of the mountains. All told, fifteen ewes have been killed by eating this weed, and they have died after manifesting the usual trembling and tucked-up symptoms. It is usually considered that the milk and meat of an animal which dies of this disease is poisonous to the human or animal that consumes them. We have not, however, found this to be the case, as the meat of the ewes which died of the disease has been fed to dogs with no ill results. One or two dogs have been induced to eat the Rich weed and have died with the same symptoms as produced in the sheep.

As stated above, we are sure that we have located at least one cause of the trouble of this disease. Some time has been spent in trying out various antidotes to see if there is a remedy for the trouble. No progress has been made so far. This important piece of investigation was closed at the end of the weed season, but will be taken up vigorously again next spring.

DAIRY INVESTIGATIONAL WORK.

Mr. Eaton has continued the dairy investigational work both at the Pender Branch Station, at Raleigh, and in the Greensboro territory in coöperation with Mr. Combs. The feeding work is being conducted at the Pender Branch Station. The manufacturing problems are being studied at Raleigh in conjunction with the creamery. The greater part of his work which relates to the cost of milk production, calf production, etc., is carried on in the Greensboro neighborhood with Mr. Combs.

The dairy herd at the Pender Branch Station is in very much better condition at present than it has ever been. We seem to be through with the troubles we have been having with contagious abortion, as we now have an excellent herd of young Jersey heifers coming on and the cows are breeding regularly. We may expect marked advancement in the efficiency of the Pender herd in the next year or so.

Value of Corn Silage as a Feed for Milk Cows.

This investigation was inaugurated three years ago at the Pender Branch Station, and is being continued at the present time. Each winter the cows have been divided into two lots, one lot being fed upon silage plus a grain ration, and the other lot upon a similar grain ration plus dry roughages. The dry roughages have consisted of cotton-seed hulls and corn stover. Mr. Eaton has recently summarized the three years work and has found that during this time there has been a difference in favor of the silage-fed cows of 3,878 pounds of milk. This was produced at a saving of $11.42 in cost of feed. This is not a marked difference in favor of silage, but the silage at the Pender Branch Station has, as a rule, been poor in quality. During the three years the price of feeds has, of course, varied very much, but wheat bran was valued at $27 to $28 a ton, cotton-seed meal $23 to $40 a ton, corn silage $3 a ton, corn chops $30 a ton, cotton-seed hulls $3.50 to $10 a ton, and stover $3.50 to $10 a ton. The actual market price of feed has been charged in every case.

The Best Feed for Wintering Young Heifers.

The farmers of the South are particularly weak in developing dairy heifers. This work is being conducted at the Pender Branch Station and in the Greensboro neighborhood in coöperation with dairy farmers. The work at the Pender Branch Station was begun December 11, 1913, and will be continued for a number of years yet, as a problem of this sort must necessarily be studied for a great number of years if conclusive and satisfactory results are to be secured. The main object in this experiment is to determine the value of cotton-seed meal in the winter ration of growing calves when the cotton-seed meal is used in limited amounts. As is well known, the majority of farmers use nothing but cotton-seed meal, so one bunch of calves is raised each year upon a grain ration of cotton-seed meal alone. The other bunch of calves is raised upon a grain ration of one-half cotton-seed meal plus one-half bran. The roughage ration is, of course, similar in the two lots. As the experiment has been under way now almost four years we have had an exceptional opportunity to study the cost of raising dairy calves up to the milking period. When the four years work is summarized it is found that the calves have been upon experiment a total of 553 days. During this time the calves which were fed upon a ration of cotton-seed meal and bran gained 711 pounds at a cost of $98.88. The calves which

were raised upon cotton-seed meal as the sole grain made a total lot gain of 11.49 pounds at a cost of $99.33. So, during the 553 winter experimental days the feed cost for the two lots has been almost identical. The cotton-seed-meal-fed calves, however, made during this time an average gain of 54.8 pounds per head more than the heifers which were fed on the mixture of equal parts of wheat bran and cotton-seed meal. I was at the Pender Branch Station a day or so ago and no difficulty was experienced in picking out the calves which were fed cotton-seed meal during the winter months. It should be explained that these calves were not fed heavy rations of cotton-seed meal, but averaged approximately a pound per calf per day.

Best Feeds for Dairy Heifers During the Spring and Summer.

Many farmers in the State are unfortunately short on pasture. This is the condition of affairs at the Pender Branch Station as satisfactory pastures have not as yet been developed. On this account we were led to study the question of feeding dairy calves during the spring and summer months. Under ideal farm conditions heifers during these months would of course graze upon pasture alone, but many farmers of the South have not reached ideal pasture conditions as yet, so the study is worth careful consideration. The calves used in this experiment are the same ones used in the winter work. Cotton-seed meal is compared with a ration made up of equal parts of cotton-seed meal and wheat bran. The calves were, of course, allowed to graze the available pasture, but very little feed was secured from them. This experiment was begun April 1, 1914, and is being continued at the present time. In summarizing his work since that date, Mr. Eaton has found that these calves have been in this experiment a total of 549 days, and during this time those which were fed upon the grain ration of cotton-seed meal alone gained 1,907 pounds at a total cost of $154, while those which were fed upon a ration made up of equal parts of cotton-seed meal and wheat bran made a total lot weight of 790 pounds at a cost of $145.31. The cotton-seed meal heifers, therefore, made the better gains, but at a slightly increased cost. This would lead us to conclude that cotton-seed meal is not so efficient during the summer months as through the winter months. This is no doubt due to the fact that the calves obtained some green grazing throughout the summer months and did not need so much cotton-seed meal. When the winter and summer work is taken together the heifers which were fed cotton-seed meal alone have made more rapid growth than those fed upon a ration made up of wheat bran and cotton-seed meal and made the gain at practically the same cost.

Cracked Corn Against Beet Pulp for Dairy Heifers.

This experiment, which was begun May 1, 1916, at Raleigh, will also prove to be of considerable interest to farmers who have a limited sup-

ply of pasture, as beet pulp will in a sense take the place of pasture. In this test the yearling heifers are divided into two lots according to age and weight. Lot 1 is to receive a ration made up of cracked corn, cotton-seed meal, and wheat bran. Lot 2 is to receive a grain ration made up of beet pulp, cotton-seed meal, and wheat bran. The roughage will be small and at the present time consists of corn stover and alfalfa hay. The experiment has not been under way a sufficient length of time to warrant any conclusion, but it is interesting to note that the hiefers in the cracked corn lot have made an average total gain of 27 pounds per head over those fed beet pulp. This gain, however, is partially offset at least by the fact that it cost $3.47 more per head to feed them. So far no difference in general appearance can be detected between the two lots.

Cost of Raising Calves in North Carolina.

This work is being done by Mr. Eaton at the Pender Branch Station and in coöperation with ten dairy farmers in Guilford and Forsyth counties. The object of this experiment is, of course, to determine accurately the cost of raising dairy animals from birth to maturity. This sort of information has not been collected in the South and it is expected that very excellent results will be secured both at the Pender Branch Station and with the farmers in the two counties mentioned. At the Pender Branch Station an exact record is kept of all feed eaten by the calves from birth until the heifers bring their first calves. The heifers are weighed at regular intervals and feeds are charged at market prices. In the coöperative work with the farmers in Guilford and Forsyth counties Mr. Eaton visits the farms twice a month and summarizes their records. The work at the Pender Branch Station has been under way about three years. In the record of twenty-two calves it has been found that when they were six months old they had attained an average weight of 264 pounds at a total cost of $13.57. When they were twelve months old they had attained an average weight of 373 pounds at a total cost of $26.12. When they were eighteen months old they had attained an average weight of 478 pounds at an average cost of $34.30. When they were thirty months old (only four have attained this age as yet) they had attained an average weight of 646 pounds at an average cost of $52.06. In the above figures feeds have been charged against the calves at market prices, including pasture at $1 a head per month. In the work in coöperation with the farmers of Guilford and Forsyth counties it has been found that it cost $31.58 to raise a dairy calf to the age of twelve months. This statement includes labor as well as feed. It should be said that none of these calves has been credited with manure produced.

Onion Flavor Investigations.

There is no one thing that interferes as much with the dairyman as the onion flavors which get into his milk and butter during the late fall,

winter, and early spring seasons. Mr. Eaton is still pursuing his investigations relative to the feasibility of overcoming these onion flavors. The work was begun in June, 1914. He has been studying the question from four standpoints:

(*a*) Relation of acidity of milk to onion flavor.
(*b*) Effect of time of milking upon onion flavor.
(*c*) Effect of feeding molasses upon onion flavor.
(*d*) Effect of feeding various preparations upon onion flavor.

This work has practically all been conducted at the Pender Branch Station. The dairymen have been advised to remove their cows from onion-infected pastures from four to four and a half hours prior to time of milking. Mr. Eaton found that this advice should not be given as onion flavors are not removed in that length of time. In one case he found a strong onion flavor nineteen hours after the onions had been eaten. Three hundred and sixty samples have been observed when molasses in varying amounts was fed in conjunction with other feeds. It was found that while molasses will materially weaken the onion flavor it will not remove it completely. Several patent preparations are recommended, Kilgarlic being among the most prominent. This preparation has a very positive effect in removing flavors. This preparation was tried thoroughly in 524 different cases. Mr. Eaton states that it removed onion flavors in 83 per cent of the samples he studied. In all, Mr. Eaton has studied 3,105 samples of onion-flavored milk during the year. Among the common remedies most thoroughly studied were charcoal, soda, mixtures of charcoal and soda, mixtures of soda and molasses, Mrs. Lee's Milk and Butter Purifier, etc. He has found that molasses in large quantities will weaken the flavor considerably. He has also found that Kilgarlic has something to do in weakening the flavor, but the other preparation and combinations are entirely without effect. These studies, however, are being continued.

POULTRY INVESTIGATIONS.

The work in poultry investigations and poultry pathology is progressing in an unusually satisfactory manner. Poultry work is now being done at Raleigh, at the Iredell Branch Station, the Pender Branch Station, and the Edgecombe Branch Station. The pathological phases and investigations which require extremely close and detailed attention are carried on at Raleigh. Very much of Dr. Kaupp's work requires his personal supervision every day, and this part is being conducted at the Central plant as it is impossible to establish scientific laboratories at the branch stations. Dr. Kaupp's work is not altogether devoted to investigational activities, but the plan is to devote the greater part of his attention to investigational problems, allowing Mr. Oliver, who is in charge of the Poultry Club work, to take care of the field phases. Dr. Kaupp, however, cannot keep entirely away from some extension activi-

ties. To illustrate: Last year he received and answered 1,852 letters from poultrymen in the State. He has also been active in encouraging plants around Raleigh, at the present time keeping in close touch and really supervising about six plants within driving distance of the city of Raleigh. He also assisted the State Hospital at Raleigh in putting in a large poultry plant and is devoting some time to superintending the operations. In addition to this he has assisted two of the farm-life schools in inaugurating poultry work, the object being to induce as many of the farm-life schools as possible to introduce this phase of live stock.

Laboratory Work.

As Dr. Kaupp is a pathologist, very much of his time is naturally devoted to studying pathological phases in poultry work. Many specimens are sent to him for examination. In this way he gets in touch with many of the interesting and destructive diseases of the State, and has an opportunity, by means of correspondence, to disseminate sanitary information over the State. An idea of the kind of specimens which come to him for study and advice can be gotten from the following statements:

1. During the year he has made a study of many kinds of tumors of the domestic fowl. Many specimens of this kind come to him.

2. Many specimens of sorehead in poultry are sent to him for identification.

3. All kinds of poultry parasites are sent to him for identification. In a study of these kinds of parasites he found that to be effective, powders and other materials must either give off the gas that will destroy the mites or the material must be in liquid form. In his investigational work he found that lice and mites will live until they starve to death in tobacco stems, Paris green, and sulphur. But when these agents are in solution they are exceedingly effective. Such agents as gasoline, naphthaline, and pyrethrum are all destructive because they give off gases. This discovery is of very great importance in controlling the parasites which bother poultry and other fowls.

4. In connection with these tests it has been necessary for Dr. Kaupp to make investigations to determine the proper dosage of some of our common drugs as nothing with poultry has been done along this line. He has found that fowls behave differently than do mammalia, as far as drugs are concerned, so each drug must be tested out to ascertain its physiological and its therapeutic dosage. During the year a study of about fifty drugs was made and the results published in the *Poultry Item.*

5. One case of Generalized Lyphosarcoma and another case of Generalized Osteomata were studied during the year. The latter case being sent by a poultry raiser from Asheville.

6. Many of the specimens sent to the laboratory had diseases of the ovaduct and abdominal cavity, especially those hens which were laying.

Dozens of other cases are coming to the laboratory all the time, such as injuries to the spine, inflammation of the ovaduct, paralysis of various nerves, pox in turkeys, limberneck, roup, etc.

The laboratory equipped for this character of work is recognized as being the best laboratory in the South, and it is proving to be of very great use to the poultry producers of the State.

Feeding Sour Milk to Chicks.

One of the greatest drawbacks to the production of chickens in the State is the prevalence of white diarrhea. This is a disease which is almost sure to appear in the flock sooner or later. In January a bulletin was issued giving results of our work in studying the effect of different kinds of sour milk in controlling white diarrhea. The chickens were placed on uninfected grounds. One lot of chickens was given Bulgarian buttermilk; a second lot was given natural sour milk; a third lot was given B. Acidi Lacti buttermilk, and a fourth lot had no sour milk of any kind. The lots of birds were hatched from eggs produced upon our Raleigh plant and were treated similarly in every respect except as to the milk. Sixteen per cent of the birds in the sour-milk lot died; 10 per cent in the Bulgarian buttermilk lot died; 12 per cent in the B. Acidi Lacti died; 24 per cent of the chicks in Lot 1, which had no buttermilk of any kind, died. There was another great difference in addition to the deaths, as the chicks which received sour milk up to eight weeks of age were all extremely vigorous—that is, those that lived—while those in the lot where no sour milk was used were weak and stunted in their growth.

Vaccinating Against Sorehead.

One of the dreaded diseases of the poultry breeders of the State is sorehead, as this disease makes it difficult to raise young chicks and embarrasses the early production of fall eggs. Recently a method was developed in Europe whereby chicks may be successfully vaccinated against sorehead. This method has been studied and used by Nevada, California, Ohio, and by our own laboratory. It consists of taking healthy single-comb cockerels, inoculating the combs and obtaining the virus from this source. We are trying to get our Raleigh plant in such shape so this vaccine can be manufactured here at least in a limited way. We are almost equipped for this kind of work now, and when we are fully equipped to begin using this kind of vaccine we will be serving the poultry raisers of the State in the same way that the hog and cattle men are served with their vaccines. The treatment is a simple one, and the farm demonstrators, after a three-day course in the laboratory, can carry the information to the farmers and farmers' wives.

Cost of Feeding Laying Hens.

Last year a record was kept upon one hundred hens to determine the exact cost of feeding them each month in the year. The morning scratch

feed consisted of equal parts of wheat and oats; the evening scratch feed consisted of equal parts of wheat, oats, and corn. The dry mash was made up of wheat bran, wheat middlings, corn meal, ground oats, and meat scrap. Each hen was given each morning and each evening one ounce of scratch feed, the dry mash being kept before them all the time. When the prices of feeds were as they were in 1915 and 1916 it was found that from 14 to 26 per cent of the hens must lay continuously to pay for their feed, varying from month to month as the price of feed and the price of eggs fluctuate.

Raising Young Chicks up to Eight Weeks of Age.

An accurate record is kept of the expense of raising chicks upon the test farms upon which we are doing poultry work as well as at Raleigh. In one of these experiments, where we had birds of different breeds, an opportunity was given us to compare the Mediterranean and Continental breeds with the American and English breeds. In this test it required 2 pounds of feed to produce 1 pound of gain on the Mediterranean and Continental chicks, while 2.1 pounds were required to produce a similar gain on the American and English breeds. At the end of eight weeks the Mediterranean and Continental chicks averaged 1.2 pounds in weight, while the others averaged 1.6 pounds in weight. It cost practically the same to make a pound of gain in the various breeds. When feed is valued at its usual market price it cost us slightly over 8 cents to make each pound of gain upon the various breeds. This test indicates that the American and English breeds grow faster and become larger than the others, but that a certain amount of feed brings the same results when fed to various breeds of chickens.

Some Fertility Experiments.

Except at this station no really careful experiments have been run to determine the time that should elapse from the time flocks are mated until the hens are producing fertile eggs. Upon many farms it is no doubt true that eggs are saved from hens which have not had an opportunity for the eggs to become fertile on account of the fact that the males have not been with the hens a sufficient length of time. Several breeds of chickens were used in this test. In the beginning the cocks were with the hens when they were removed and the fertility of the eggs tested day after day until no fertile eggs were produced. When no fertile eggs were being produced the cocks were placed with the hens again and the eggs again examined until fertile ones were laid. In this test it was found that under ordinary conditions from 80 to 90 per cent of the eggs are fertile when the cocks are with the hens continuously, and from 80 to 90 per cent of these fertile eggs hatched. When the cocks are removed from the hens fertility rapidly declines, and it was found to be inadvisable to save eggs for hatching after the males had been removed from the hens for five days. We are certainly safe in saying

that the effect of mating hens with scrubby or mongrel cocks is entirely removed within fifteen to eighteen days. When the fertility had entirely disappeared and the cocks were placed with the hens it was found that eggs began to come fertile about the fifth or sixth day.

Feeding Cotton-seed Meal to Laying Hens.

This long-time test is being continued, having been begun November 1, 1915. The object is to determine the effects of cotton-seed meal on the health, vigor, and egg production. One lot of hens is fed a ration made up of 30 per cent cotton-seed meal; a second lot is fed a ration made up of 5 per cent cotton-seed meal; a third lot is fed a ration which has no cotton-seed meal at all. In the first lot, where a heavy ration of cotton-seed meal is being used, 26 per cent of the hens died the first year; in the second lot, where a ration made up of 5 per cent cotton-seed meal is used, 12 per cent of the flock died; in the third lot, where no cotton-seed meal at all is being used, only 10 per cent of the birds have died the first year. There has not been so far a marked difference in the amount of eggs produced.

Breeding Work with White Leghorns.

The first year's work with White Leghorns was incorporated in my last report. This year forty of the best Leghorns of the old flock were selected for the second year's work. These hens were mated with a grandson of one of the greatest egg producers of the country, Lady Purdue. The object of this test is to breed up a better egg-laying strain of White Leghorns, and after this is done to disseminate this strain of good egg layers among the farmers of the State. We have not, of course, gone far enough to know just what progress we are making in building up this egg-laying strain as the old flock, about which we knew nothing, was turned over to us only two years ago. Trap-nest records, however, are kept of all these hens, so we know exactly what each hen is doing. The flock we began with when the poultry work was given over to the Animal Industry Division produced an average of 52 eggs a year. This, of course, was very low. It is probable that the offspring from these low-producing hens will be somewhat greater producers themselves, provided the males we secured really came from high-producing stock.

Pounds of Feed Eaten by Various Breeds and Pounds of Manure Produced.

Accurate records have been kept to determine the amount of feed eaten by our various breeds of chicks, the cost of feed, and the amount of manure produced. Records are being kept of Silver Campines, Silver Wyandottes, Golden Wyandottes, Columbian Wyandottes, Buff Plymouth Rocks, Partridge Plymouth Rocks, White Plymouth Rocks, S. C. White Leghorns, and some mixed lots. The lowest consumption of feed has been with the Silver Campines. These chickens ate 57.6 pounds per

head. The most expensive breed was the Buff Plymouth Rocks, measured by the cost of each dozen eggs produced. We have not, however, gone far enough with this work to draw definite conclusions.

Hens are very heavy producers of manure. Our hens have, on the average, produced 22 pounds of manure per head per year.

Marketing Problems.

Our surplus eggs are, as a rule, shipped to Boston, New York, and Washington, D. C. We are making these shipments to gather information as to shipping by parcel post and to work out the best material to be used in shipping eggs. We have found that such materials as sawdust, bran, and cotton-seed hulls pack so closely in a box that there is no spring to the material about the eggs, hence about 10 per cent of the eggs shipped in these materials has been broken. These materials are particularly unsatisfactory when breeding eggs are to be shipped. When, however, our eggs were wrapped in soft paper, felt, prairie hay, or moss, very few eggs were broken.

Soybean Meal as a Feed for Poultry.

(Pender Branch Station.)

At the Pender Branch Station fourteen broods of chicks were used in this test to determine the value of soybean meal and sweet milk. We are receiving very many inquiries as to the value of soybean meal for feeding chickens, and this test was outlined in order to enable us to give farmers definite information as to this point. Accurate data was kept until the birds were eight weeks old. The soybean-meal-fed chicks were compared with oat-fed-chicks, and it was found that soybean meal practically takes the place of rolled oats and is very much cheaper.

Peanut Meal as a Feed for Poultry.

(Edgecombe Branch Station.)

We are also getting inquiries continually asking us about the value of peanut meal as a feed for small chicks and laying hens. In the early part of the summer a test was run at the Edgecombe Branch Station as a preliminary study. Peanut meal was fed along with equal parts of corn meal and ground oats. This lot was compared with other lots of chickens which were fed a ration of ground oats and corn meal, all of the chickens being given buttermilk. It was found that peanut meal was exceedingly efficient for growing young chicks up to eight weeks of age as our chicks which were raised upon this ration were very much larger than those which were raised upon corn meal, ground oats, and buttermilk alone; in fact, the birds which were raised upon peanut meal at the end of eight weeks averaged a little over a pound in weight, while those which were raised upon a ration with the peanut meal left out averaged only .7 of a pound in weight.

Dry Lot Against Range Handling and Feeding of Laying Hens.

(Iredell Branch Station.)

At the Iredell Branch Station the hens are divided into two flocks, one flock is allowed the freedom of the farm, while the other lot is confined in relatively small areas. This kind of an experiment is of particular interest to poultry raisers who live close to or in the suburbs of small towns and cities. The object of this long-time test is to determine the effect, if any, of this confinement upon egg production, vigor, and troubles in poultry diseases. This work, of course, has not continued a sufficient length of time to get marked results yet, but during the last season the hens which had the run of the farm produced many more eggs than those which were confined. This was the case also with the same kind of an experiment which is being carried on at the Pender Branch Station.

HORSE AND MULE WORK.

The horse and mule work of the State is, of course, dragging because of the fact that we have no one to look after it. We are, however, doing some investigational and field work with horses and mules. Our investigational work is being conducted at the Iredell, Pender, and Edgecombe Branch Stations. The work at the Iredell Station has now been under way a little over two years; the work at the Edgecombe Station will have soon been under way two years, and the work at the Pender Branch Station was begun three years ago. Throughout all of this work one idea runs; that is, we are trying to determine the place of cotton-seed meal in a ration for work horses and mules. In this study we, of course, incidentally get other information that will be valuable. A complete record is now kept of the amount and kind of feed eaten by each horse at each branch station as well as the amount and kind of work each horse does each day. When this information is all gotten together after several years it will be a valuable economic study of the cost of keeping work animals upon farms and the amount of work they do. The work horses and mules at each one of the branch stations mentioned above are divided into two lots. One lot is fed upon a ration in which no cotton-seed meal is used; the other lot is fed upon the same kind of ration exactly except that cotton-seed meal makes up a part. So far we have found that while cotton-seed meal can be used in very limited amounts, we cannot as a rule induce a horse or mule to use more than one pound a day for any length of time. This one pound, however, has proved to be an economical addition to the ration, and has also had much to do with maintaining the horses and mules in better condition. The saving in money, however, is not the chief advantage in using cotton-seed meal, or at least it does not appear so at the present time. It seems that the chief advantage will be that the horses which eat cotton-seed meal stay in better condition. This is indicated plainly during the spring months, as the animals which eat cotton-seed meal shed off earlier and smoother

than those which do not eat it. Probably next year our information will be full enough to warrant placing it before the public either in bulletin or newspaper form.

MEETINGS ATTENDED AND NUMBER OF PEOPLE REACHED.

Approximately 20,000 personal letters have been addressed to the Animal Industry offices during the year. In answering these letters we come in touch with many people, and we also meet thousands of people in farmers' institutes and other gatherings. The following summary gives a fairly accurate idea of the number of public meetings attended by the various officers of the Division during the year:

	Meetings Attended	*Total Attendance*
General Office	18	3445
Dairy Farming Office	57	4622
Dairy Investigations		
Beef Cattle and Sheep	50	3500
Poultry Investigations		
Pig Clubs	82	4459
Poultry Clubs	114	8494

PUBLICATIONS.

The following publications have been issued during the year:

New edition of Pig Club Manual.
Feeding Skimmilk, Buttermilk, and Whey to Hogs.
Feeding the Sow and the Suckling Pig.
Soybean Pastures for Hogs.
New Edition of Curing Meat on the Farm.
Dairy Records, or Feeding the Farm Cow, Circular No. 33.
Colony Hog Houses.
Methods of Dehorning Cattle.
From Wool to Cloth.
Hog Houses and Equipment.
The Proper Methods of Housing and Handling the Farm Flocks.
Some Further Studies of Chick Mortality and When to Feed the Baby Chick.

Respectfully submitted,

Dan T. Gray,
Chief, Animal Industry Division.

REPORT OF THE DIVISION OF ENTOMOLOGY.

To the Director:

The following report gives a summary of work on the entomological projects under my charge for the year ending June 30, 1916.

1. INSECT CONTROL ON TEST FARMS.

All peach orchards were examined in late winter, borers removed, and trees mounded at base. In late winter, spraying treatment to control San José Scale was given to all fruit trees, and this followed by later sprayings to control caterpillars, codling moth, curculio, and fungous diseases. It is believed that the general condition of the orchards is good so far as insect pests is concerned, though the loss of an occasional tree is to be expected.

2. PUBLICITY WORK.

Although no publications have been issued during the year, the demand for bulletins already issued has been gratifying. During the spring (1916) over 2,500 copies of the Bulletin on Orchard Spraying were distributed by request, mainly in lots to county agents, but many were mailed directly to farmers.

Several weeks in January and February were devoted to farmers' institute meetings, where talks were given on the more important insect pests, methods of controlling them, and the general principles governing the development of insects and the application of remedies.

3. ADMINISTRATION AND CORRESPONDENCE.

Under this head comes the routine office work, and much time is always consumed in consultations with (1) those who come in person for information, (2) with assistants, and (3) coworkers in other offices. There is also the preparation of reports, oversight of expenditures, purchases, expense accounts, examination and filing of reports on inspections, and of certificates from outside nurserymen. Finally, there is the regular task of general correspondence, much of which is technical or semitechnical in character and must be carefully worked out.

4. EXTENSION WORK—ORCHARD INSPECTION.

During the fiscal year under review, twenty-one counties were visited in this work, fifty-five orchards inspected, these containing a total of 115,851 trees. San José Scale was detected in thirty-seven of these orchards, containing 71,733 trees. It is a relief to report that spraying to control this and other pests is becoming more and more common among the fruit growers, and nowhere is the fruit industry now really threatened by the widespread presence of this pest. This is proven by

the conditions in Moore County, where this pest was rampant in the fine young peach orchards eighteen years ago. Some of these same orchards are still in bearing, and our inspections of the present year included a number of newly planted orchards in that county, showing that the industry there is still on a solid basis.

5. EXTENSION WORK—ORCHARD-SPRAYING DEMONSTRATIONS.

Public demonstrations in the spraying of fruit trees to control insect pests have been held in a number of orchards. These are usually arranged in coöperation with the county agents, and the work of the year has included demonstrations on both apple and peach trees.

6. REGULATORY WORK—INSPECTION OF IMPORTED NURSERY STOCK.

Thirty-seven shipments from foreign countries have been inspected during the year—from Holland 14, Belgium 11, France 11, Japan 1. The following pests were intercepted: Crown Gall, European Tussock Moth, European Pear Scale, Oyster-shell Scale, and a species of Soft Scale. Various harmless insects were also found.

7. REGULATORY WORK—INSPECTION OF STATE NURSERIES.

Fifty-nine nurseries located within the State were licensed after due inspection.

8. INVESTIGATIVE WORK—LAUNDRY SOAP AS REMEDY FOR APHIDES.

This is specified as a merely incidental project. No new data has been accumulated during the year.

9. INVESTIGATIVE WORK—INSECT SURVEY.

This project, worked upon piecemeal whenever opportunity offers, is making slow but substantial progress. Part of the collections are identified by ourselves, but much must be sent to specialists, and is subject to delay. During 1915, over 250 native species not before listed were added to the card-catalogue record, and upwards of 100 or more were added during the first half of 1916. A tabulation on May 1, 1916, showed 4,843 species of North Carolina insects listed. It is believed that few States can make a better showing in this line of work.

10. INVESTIGATIVE WORK—PEACH SPRAYING.

Owing to late frosts and early drought, the peach crop was so scant in the orchard at the Iredell Branch Station that the tests which have been under way there were not conducted during 1916. The data of the two preceding years is in hand, and it is expected to add to this as opportunity offers. It seems best to make all the tests of this series in this same orchard.

11. INVESTIGATIVE WORK—POTATO SPRAYING.

This work was carried through the season of 1915 and results noted. It is being done at the Buncombe Branch Station. Plantings were made in spring of 1916, but owing to disastrous floods (which have occurred since the fiscal year covered by this report) the results of the work for 1916 will be of little value.

12. INVESTIGATIVE WORK—PECAN INSECTS.

The work on this project continues favorably, and much data have been accumulated concerning the species of insects which attack the pecan in this State. Their habits, life-histories, and injuries have all been studied. Tests for the control of several species have been made. Notes, photographs, and biological collections are being accumulated.

13. INVESTIGATIVE WORK—CORNSTALK BORER.

The work of the year has established the approximate life-history of this insect, number of broods, time of emergence and egg-laying by the adult insects, and specific data has been secured showing the difference in injury in plots planted at different dates. Notes, photographs, and collections are being accumulated.

. . . . . .

As in the previous report, I am glad to acknowledge the efficient work of those associated with me—Mr. R. W. Leiby in Investigations, Mr. S. C. Clapp in Inspections and Field Work, Mr. B. Szymoniak in Demonstrations.

Respectfully submitted,

FRANKLIN SHERMAN, JR.,
Chief, Division of Entomology.

REPORT OF ENTOMOLOGIST.

To the Director:

My time during the past year has been devoted exclusively to the three Adams' Fund projects: the Corn Bill Bug, the Gloomy Scale, and the study of the Cowpea Weevils.

The Corn Bill Bug project has been finished as far as practical at the present time, and a report for final publication as a technical bulletin is all but ready to be submitted for publication. There are still a few points in this project that have not been completed, but there is no reason why this project should not be closed so that more time can be devoted to the other projects.

The Gloomy Scale and the Cowpea Weevil projects have progressed as satisfactorily as could be expected. A new and more satisfactory method of following the life-history of the Gloomy Scale has been devised, so that in the future we will be able to follow the various stages of this insect in greater detail. An additional point of advantage in the new method is that the scale under observation will be under perfectly natural conditions. A parasite of this scale has been doing effective work in controlling the scale and a great many observations have been made in its life-history. There is also a predaceous mite which seems to be rather effective in controlling this scale at times.

Most of the work that has been done on the Cowpea Weevil project has been devoted to a study of the egg-laying habits of the adult and to a consideration of practical remedies for its control. A satisfactory remedy has been discovered in air-slacked lime, which is not only cheap, but easily applied, and so far as our observations have gone far more successful than any remedy so far suggested.

Respectfully submitted,

Z. P. Metcalf,
Entomologist.

REPORT OF DIVISION OF HORTICULTURE.

To the Director:

I herewith submit the report of the experimental work of the Division of Horticulture for the fiscal year ending June 30, 1916.

PECAN WORK.

The work with pecans, as originally begun nine years ago, to ascertain the possibilities of commercial pecan growing in North Carolina has progressed satisfactorily. The test orchards have on their eighth year come into commercial bearing. The production records of these orchards are as follows:

Third year: A few nuts on three varieties.

Fourth year: A scattering of nuts on several varieties.

Fifth year: Several trees bore a pound of nuts each, some 1½ pounds, and one tree bore 2½ pounds.

Sixth year: A late spring frost caught the new growth just as it was putting out and there was no crop that season.

Seventh year: There was 50 pounds of nuts gathered from 300 trees.

Eighth year: The crop was 815 pounds.

Each successive season has confirmed the value of Stuart and Schley as varieties of pecans suitable for conditions in Eastern North Carolina. Many varieties which have been found unsuited to our conditions are now being topworked to these varieties by the methods outlined in our Experimental Bulletin No. 224, "Topworking Seedling Pecan Trees."

The test orchard in pecan breeding work set in the spring of 1914 has made a very satisfactory growth this last season.

PEACH WORK.

Considerable data have been collected this last season from the variety orchards on the test farms and from commercial orchards throughout the State.

The work in breeding new varieties has pushed vigorously this spring, and a large number of crosses have been made to produce improved varieties, especially of the earlier maturing types. We are endeavoring to produce early freestone varieties of both white and yellow-flesh peaches and also to produce varieties hardier in bud. For the further carrying out of this work, we are now building up a collection of peaches of foreign sorts as introduced by the Bureau of Seed and Plant Introduction of the United States Department of Agriculture.

THERMAL WORK.

This is the fifth season that we have had our self-recording instruments recording data on thermal conditions in orchards of Western

North Carolina. After the final survey of the stations this coming season, it is intended to make a summing up of the data already obtained. To facilitate the study of the data recorded, topographical maps of the conditions surrounding each of the recording stations are now being made by the Division of Engineering.

SWEET POTATO WORK.

Very satisfactory results were obtained this last winter in the storage of sweet potatoes in the model storage house constructed last fall. Our experiments, though not yet completed, indicate that the control of disease conditions in the bedding of sweet potatoes and care in harvesting are the two prime factors in the storage of this crop.

IRISH POTATO WORK.

Work has been continued in the experimental work with Irish potatoes as outlined in the project last year. The material for hill and tuber selection has increased to such an extent that this phase of the work is demanding a great deal of time and attention. Very interesting results are promised as the result of this work.

The recent floods which devastated the mountain sections of North Carolina practically ruined all the potato and cabbage experiments in progress at the Swannanoa Branch Station. This was especially unfortunate as the work in tuber unit selection was of such a nature that the selections of previous years were lost. A valuable collection of foreign varieties imported by the United States Department of Agriculture that we were testing for them on the Swannanoa farm was also washed away.

The experiments with early potatoes being conducted at the Pender Branch Station were harvested just before the flood and very satisfactory results were obtained.

Work along other lines is continuing as outlined in former reports.

W. N. Hutt,
Chief, Division of Horticulture.

REPORT OF THE HORTICULTURIST.

To the Director:

The work has been conducted chiefly along the line of research outlined in previous reports. The projects conducted under the provisions of the Adams Act during the year are as follows:

1. A STUDY OF SELF-STERILITY IN BLACKBERRIES AND DEWBERRIES.

This project has been completed during the year and manuscript submitted for publication.

This project has established the facts: that correlation between hybridity and loss of self-sterility does exist among blackberry and dewberry varieties; that varieties derived from Rubus trivialis are generally self-sterile, while those descended from Rubus villosus, on the contrary, are self-fertile, and that all that is necessary in order to avoid failure in the setting of fruit by reason of impotent pollen is to employ the *mixed planting* method employed with other fruits, in which at least one row in five should be of a different variety.

2. A STUDY OF TRANSMISSION OF CHARACTERS IN HYBRIDS OF ROTUNDIFOLIA GRAPES.

The work with this investigation, the chief project of interest at this point, has developed in such a way as to make it highly desirable to subdivide it for future work. The outlines of the several investigations as planned have already been submitted and include studies of the inheritance of sex, of productivity, of color, of size of fruit, of qualities of fruit and vine, and the determination of the limits of hybridization with respect to this class of grapes.

Respectfully submitted,

J. P. PILLSBURY,
Horticulturist.

REPORT OF THE DIVISION OF VETERINARY SCIENCE.

To the Director:

I beg to submit the following report of the Veterinary Division for the fiscal year ending June 30, 1916.

This Division, in reports for the past two or three years, has made mention of its findings regarding the wide prevalence of so-called "contagious abortion" infections. As previously stated, evidence of such infection has been found in a large per cent of the herds of cattle in the State. Likewise, similar infections appear to be prevalent in horses, swine, and sheep.

The major part of the investigational work during the past year has been in further studies concerning this infection, and with special attention to dairy cattle. It has been attempted to determine the effects or results of the infection, its extent or prevalence, the means or methods of detecting it, and measures for control of the results of the infection, if not the control of the infection itself.

RESULTS OF THE INFECTION IN CATTLE.

As previously reported, we are convinced that the results of the infection are extremely variable, and that not all of the possible results have been positively determined. Many animals carrying a specific infection (as the Bacillus abortus in cattle) show no clinical evidence of the infection whatever, others abort at various periods of gestation or they may give birth to weak or dead young at full term, still others show signs of inflammation of the uterus following calving associated, in many cases, with retained after-birth. Again, sterilities, both temporary and permanent, are among the most serious results of the infection. Some of the above results may be due at times to causes other than specific infections. Our observations, however, agree with the later views on the subject, namely, that a very large per cent of such are due to specific infections and not from the numerous causes heretofore held in suspicion. Therefore, such agents as frights, injuries, repugnant sights, certain feeds, and even drugs purported to cause abortion, play only a secondary part. Their greatest influence, no doubt, is felt when the uterus of the animal is sufficiently altered by infection or is mechanically opened.

The relation, if any, between this infection and the almost universal granular venereal disease of cattle has not been determined.

The frequency with which this organism is found in new-born and in the milk of some cows lends some color to the theory that certain forms of scours of the new-born may be due to this cause.

Again, as to whether any of the numerous cases of inflammation of the udder are due to this organism remains for further investigation.

Numerous visits to the abattoir and many examinations of sterile cows

have been made to determine the conditions of the ovaries and uterus. In many cases, one or both ovaries have been found to contain a persistent yellow body (*corpus luteum*) or one or more cysts. The latter have been found to result from an unruptured egg (graafian) follicle or from a degenerated yellow body. In some examinations the uterus has been found to contain pus, in some others a catarrhal inflammation existed.

EXTENT OR PREVALENCE OF THE INFECTION.

Some seventy dairy herds scattered at thirty-five points throughout the State have been visited. About 2,500 cows and heifers were examined for evidence of granular venereal disease, and the history was obtained, as far as possible, as to abortions, retained after-births, and sterilities in each herd. Very few cows and heifers failed to show evidence of the granular veneral disease and few herds were reported as having no abortions, retained after-births, and sterilities.

MEANS AND METHODS OF DETERMINING INFECTION.

In addition to detecting the infection through clinical symptoms, effort was made to recognize it by means of subjecting the blood serum of cattle to laboratory tests. Two hundred and three samples of blood from cattle in various parts of the State were secured and subjected to the agglutination and complement fixation tests, using the Bacillus abortus as the antigen. As the result of the above tests 65 per cent gave positive reactions with one test or the other; 17 per cent gave negative reactions to both tests, and 18 per cent gave suspicious reactions. While these laboratory tests enable one to detect a good many cases of infected animals, we are inclined to believe that not all cases can be recognized by these tests as they are now applied.

MEASURES FOR CONTROL OF THE RESULTS OF THE INFECTION.

Owing to the irregularity in the course and in the results of this infection, the apparent effects of measures for its control have often been misjudged. Likewise, owing to the extent to which the infection exists, much of the former advised measures for control have been found unwarranted. For the present, we will largely have to be content with the control of the effects of the infection in maintaining or in securing a quiescent state of the infection. This will be accomplished to a great extent through the employment of good hygienic and sanitary measures. We have observed in a number of herds where new introductions were frequently made that abortions, retained after-births, and sterilities were likewise frequent. On the other hand, we observed a number of times that where results had been previously common they became quite seldom when new introductions to the herd were not made.

The active measures for control of the results of the infection will probably be some of those useful in overcoming many of the cases of

sterilities, namely, when sterility is due to a persistent yellow body, or cystic state of the ovary, treat by massaging the affected ovary or ovaries through the rectal wall; if due to alterations in the mucous membrane, or secretions of same, of the uterus or vagina, treat by flushing out with mild antiseptics.

It has been hoped for some time that a biological product would be found to effectively produce an immunity to the infection, but such has not been produced as yet. Nevertheless, the fact must not be overlooked that most cows that abort do so usually, once or twice, with their early pregnancies, afterward apparently assuming a tolerance to the infection and carry future young to full term.

While considerable light has been thrown upon the general subject of this infection much remains for future investigations.

Several laboratory examinations of tissues, parasites, feed, and milk have been made for practicing veterinarians and others.

We have been called in consultation by eighteen different veterinarians in the State. Nine fairs and live-stock meetings were attended and classes of the live stock exhibited, usually horses and mules, were judged. The usual correspondence with veterinarians and farmers relative to the diseases of live stock has been conducted. At the request of those in charge of animals belonging to the Station, forty-eight visits were made to attend sick or injured animals. Seventy-four autopsies were conducted and forty-three sheep were treated for stomach worms with copper sulphate, gasoline, and thymol.

Respectfully submitted,

G. A. Roberts,
Veterinarian.

REPORT OF DIVISION OF PLANT PATHOLOGY AND BACTERIOLOGY.

To the Director:

I submit the following report on the work of this Division for the fiscal year ending June 30, 1915.

Soil Bacteriology (in coöperation with the Division of Chemistry).—Work has been in progress along the lines previously outlined. Special attention has been given to the relation between the rate of nitrification and the character of the nitrifying solutions.

Apple Root Rots.—Field and laboratory studies have been confined to one of the organisms productive of root rot. A complete report of these studies should appear within the near future.

Lettuce Drop.—Comparative studies have been made of the Sclerotinia attacking lettuce and the one affecting clovers and alfalfa. Considerable data have been secured on the relationship of these organisms.

Watermelon Wilt Control.—Selections have been made with the view of improving the characters of the rind of the North Carolina wilt-resistant melon. Packets of this seed have been sent to a number of melon growers in the State.

Control of Tobacco Wilt (in coöperation with the U. S. Department of Agriculture).—The results of crop rotation indicate that successful control may be accomplished by this method. Several new cultivated and weed hosts have been found. Laboratory and field studies have confirmed these findings. Selections have been made to find a variety of tomato resistant to the wilt organism.

Work on the Plant Disease Survey has been conducted in coöperation with the United States Department of Agriculture. Considerable time has been devoted to answering letters of inquiry relative to the nature and means of control of plant diseases.

Prof. H. R. Fulton severed his connection with the Department December 31, 1915, and Dr. F. A. Wolf was appointed to his place. No other changes in the personnel of the staff have been made.

Respectfully submitted,

FREDERICK A. WOLF.

REPORT OF THE DIVISION OF MARKETS AND RURAL ORGANIZATION.

To the Director:

The following report on the work of the Division of Markets and Rural Organization for the fiscal year ending June 30, 1916, is submitted herewith.

MARKET QUOTATIONS.

The Price Report, which has been published weekly, includes quotations on corn, oats, Irish and sweet potatoes, apples, Western creamery and North Carolina creamery butter, eggs, poultry, live hogs, cotton, cotton seed, and cotton-seed meal for sixteen North Carolina towns, and a scale of differences for different grades of cotton for the leading markets of the United States. A much greater demand exists for this Price Report than we are able to fill on account of the cost of mailing it. The Atlantic Coast Line, Seaboard, and Norfolk Southern railroads are distributing these reports.

During the summer a daily wire service was established in coöperation with the Office of Markets and Rural Organization, U. S. Department of Agriculture, for strawberries, Irish potatoes, and cantaloupes. This service has proved of value to both growers and shippers in preventing the sacrifice of products on a glutted local or distant market.

In the cotton-grading work we are informing farmers this year of the points they ought to receive on or off from middling for the grade of their particular bale of cotton. Knowledge of market prices is impossible apart from knowledge of grades. If different markets are grading a product differently the quotations can mean little except to the few on the inside who may be acquainted with conditions. Hence the cotton-grading work is going to be of immense value in establishing for this State a system of market quotations which shall be based upon uniform grades according to the United States cotton standards.

LISTING SELLERS, BUYERS, AND RECEIVERS OF FARM PRODUCTS.

This last year we have adopted the policy of giving as little time as possible to listing farm products. The Experiment Station printing funds were exhausted and so the Market Bulletin has not been issued since April. However, we believe that the listing of ungraded stock has a doubtful advertising value. Nothing advertises the products of a State like a constant, persistent, standardized supply of them put on any given market by a responsible organization of producers who are in a position to guarantee uniformity of grades.

Formerly we have relied for knowledge of trade conditions on correspondence; this year we are coming into closer touch with actual conditions through personal visits to leading markets in North Carolina

towns and in Northern cities, especially those of Chicago, Pittsbugh, New York, Boston, and Philadelphia.

The value of this work cannot be overemphasized as this office can thus get information concerning agencies and conditions which do for all shippers, but which costs too much for the individual shipper or small organization to obtain.

ORGANIZATION FOR MARKETING STRAWBERRIES.

This spring the Division furnished a manager for marketing strawberries for the Chadbourn Fruit and Produce Exchange, one of the two strawberry exchanges which we had been promoting since the close of the 1915 season.

At an enthusiastic meeting at the end of this season's business many growers from Chadbourn and Tabor reported their satisfaction in the work of both exchanges. The Chadbourn Exchange consigned 2,675 crates, mainly to New York, and received an average price of $3.34 per crate from April 20th to May 15th. Twenty-six cars were consigned altogether by the Chadbourn Exchange and 8,454 crates were sold locally by the Tabor Exchange. The average price received by the Tabor Exchange was $2.54 per crate for the whole season. The figures given are not, however, comparable as they represent different dates of shipment.

The Chadbourn Exchange had the more difficult task of establishing a reputation in Northern markets. Dependence upon a local market is likely to make a monopoly of that market, and in the long run must mean low prices. Brokers can combine to depress the prices they will pay to an organization just as well as to the individual grower. The organization like the individual is helpless unless arrangements are made with reliable houses in outside markets to handle a product regularly throughout the season; this will give a choice of markets.

As soon as our North Carolina strawberry organization has established a reputation on leading markets for uniformity and reliability of pack, the next step will be to sell by wire. The Ozark Fruit Growers' Association, the largest strawberry organization in the United States, sells most of its berries by wire or through its own agents on the leading markets. This association shipped 406 cars during the year 1915. It will be in the interest of better distribution and stronger organization for all associations in the North and South Carolina strawberry belt to sell through one joint sales agency, as do the twenty-two associations of Missouri and Arkansas, which belong to the Ozark Fruit Growers' Association.

In general, through this year's organization for marketing, the grade of strawberries of the whole section was improved. Prices were about a dollar a crate higher where there was an organization than where there was none, and the length of the season in which shipments could profitably be made was extended. North Carolina need not be simply a "filler" between the time of sale from other sections if agents are guaranteed regular and reliable shipments. Where, as in previous years, the pack

has not been maintained as high as that of our competitors, our berries have been dropped in favor of those of Virginia.

The Seaboard Air Line Railway is coöperating to establish a strawberry exchange at Bladenboro. Other sections are planning to organize locals, which shall use a common manager as sales agent.

THE ORGANIZATION FOR MARKETING IRISH AND SWEET POTATOES.

The Carolina Potato Exchange organized by the Division of Markets last year has this year just finished a successful season in marketing 2,647 barrels of Irish potatoes.* The average net price received for the entire crop was $3.05 per barrel. This price is about a dollar above that received at some points where there was no organization. Growers at the different shipping points in the State should make arrangements to pay cash for fertilizer and seed so they will be free to sell through the exchange. A branch should be organized to ship through the exchange wherever the amount of shipments is enough to justify the pro rata expense for inspector and manager.

The exchange shipped 10,192 barrels of sweet potatoes this year at a net average price of $1.96 per barrel. There was a considerable variation in prices, in part due to lack of uniformity of grades. This defect should be corrected another year by the employment of more inspectors.

Last year this Division furnished two of its employees to act as manager and general inspector for the exchange, and paid their salaries and expenses. This year we furnished the manager, but the exchange paid his salary and all other expenses, and had a net balance of $460.18 above all expenses.

We had planned this year to start an exchange for the apple growers like that for the potato growers, but on account of the scarcity of funds we did not employ additional men for this purpose. At the same time we have found it impossible to make use of our manager of the Carolina Potato Exchange because the two crops overlap in their periods of marketing. For this reason it has not been possible to line up the apple growers for an exchange this year. As soon as we establish an exchange a daily market news service to report apple prices will be maintained at the same time.

COTTON GRADING, WAREHOUSING, AND MARKETING.

During the year 1914-1915 we graded cotton for five counties through the coöperation of the Office of Markets, United States Department of Agriculture, county commissioners, and ginners. This year we offered to grade cotton for any county whose commissioners would make the necessary appropriation of $300. Twenty-one counties responded, viz.: Beaufort, Cabarrus, Cleveland, Craven, Cumberland, Edgecombe, Greene, Halifax, Lenoir, Mecklenburg, Nash, Northampton, Onslow, Pitt, Robeson, Sampson, Vance, Wake, Warren, Washington, and Wil-

*For a complete account of this exchange see the Farmers' Market Bulletin for October, 1915.

son. The grading offices for these counties are at Charlotte, Fayetteville, New Bern, Raleigh, Tarboro, Weldon, and Wilson. The plan is to cover the State by dividing it into eleven cotton-grading districts.

The plan followed this year, as in the two previous years, has been to rely upon the ginners to draw and send to the grading offices samples of all cotton ginned, the Office of Markets furnishing the necessary containers and other supplies. The first two years the ginners were asked to send these samples in as a part of their ginning service. This year we have agreed to compensate them by paying them 2 cents for each sample and furnishing them with coupon tags.

The coöperation of ginners has been complete in no county, though much better in some than in others. The cotton ginned last year in the five cotton-grading counties was 130,855 bales. Of this we graded 30,000 bales, or 22.1 per cent. While our compensation to the ginners has increased the number of samples received, still the fact remains that some ginners do not furnish samples. For this reason we recommend that the next Legislature pass a law to license ginners, and to require all ginners to be bonded, and, finally, to require all ginners in counties which make an appropriation for the cotton-grading work to draw samples of all cotton ginned and send them to the office of the State graders, and perform the same service in other counties upon application of any owner of cotton.

Last year, through this same coöperative work, we also graded 13,000 bales of cotton from eighteen of the leading cotton markets. In this case we did not inform the farmers of the grade of their cotton. In comparing the prices received for cotton we found that farmers received on an average of $1.15 per bale more on all markets where they knew the grade of their cotton than did farmers who did not know the grade of their cotton.

This grading work has proved very popular with farmers where it has received a fair trial. If they would wait for the grade certificate to reach them before selling their cotton the knowledge of its grade would have both an educational and a money value to them, even in years of high prices. The method practiced by local buyers of not buying on grade, but of averaging the grade, is simply a way of dodging the payment of market prices and a means of profit to the buyer and of loss to the producer. As buyers become more acquainted with the cotton-grading service they have become more inclined to coöperate in buying on grade and to acknowledge generally the far-reaching value of buying cotton strictly according to its merits.

In a survey made of the mills of the State during the last two years it has been found that the mills are buying largely their lower staples from within the State and the higher staples from outside the State, as is seen by the table given below:

	Below 7/8	7/8	12/16	1″	1 1/16 and better
Production	28,000	400,000	160,000	152,000	56,000
Consumption ...	27,000	300,000	180,000	234,000	144,000

In order to give our mills and farmers the mutual advantage of no, or small expense for freight, the Division of Agronomy is coöperating with this Division to conduct cotton-seed selection in different parts of the State, so as to improve the staple of cotton. Our average staple last year for the cotton graded was found to be a little less than $^{15}/_{16}$ inch.

A second survey of the mills is being made this year to determine how far the mills obtain the staple and grade of cotton they contract for. Enough has already been done to prove that mills as well as farmers and buyers are often surprisingly without knowledge of the class of cotton they are buying. Through a third survey many mills have indicated their interest in securing the services of this Division in settling their disputes.

One of the greatest problems in the cotton-grading work is to secure competent graders for five months employment. This problem will solve itself as the mill business, warehouse work, and cotton-marketing organizations develop so as to make necessary the employment of graders for all the year.

The cotton-grading work shows the necessity for developing cotton-marketing organizations along the lines of the Edgecombe Cotton Exchange which this Division promoted in the fall of 1914. It was found in the season of 1914-1915 that the larger producer, who could sell in lots of ten or more bales, obtained 88 cents to $1.45 per bale more than the farmer who only sold one bale at a time. This is partly due to the fact that the larger producer naturally gets better consideration through his dealing on a cash basis and through his being better able to look out for other markets whenever he is not offered the market price for his particular grade of cotton. The Edgecombe Cotton Exchange offers to sell all cotton for its members according to grade. Government grades will be more rapidly recognized, and farmers will be able to save thousands of dollars if they organize to sell their cotton on grade. The spare time of our cotton graders should be given to helping farmers find a market where their grade will be recognized, whether that market be local or distant.

When this State is completely covered by our cotton-grading work, the eleven graders necessary to do this work will have plenty of time to look after the development of an efficient warehouse system for the State. The grading offices are usually placed at the best concentrating points for receiving samples. The same points will be the best for concentrating cotton for storage. If the railroads will grant the storage in transit privilege for these points as provided for by law, then these points should have adequate warehouse facilities for the storage of the cotton produced within these districts.

These towns, also, will have a public water-works, which will make it possible for warehouses to have a sprinkler system, so as to reduce the insurance to a minimum cost. Insurance in the country is too high to make warehousing of cotton profitable; besides, cotton can be better sold if collected and classed in large, even-running lots. While the ware-

house surveys made in coöperation with the Office of Markets, as well as the one made by the North Carolina Division of Markets this year, show the need of additional cotton warehouses, the above plan will help to bring about a systematic development of warehouse space to fill this need.

Farmers, bankers, and buyers in many places have expressed an interest in working with this Division in promoting warehouses under the Coöperative Law of the State. According to this law, all profits above the expense of operation will be prorated to the users in proportion to the amount each stores.

If warehouses are mainly located at the same places as cotton-grading offices the graders can personally draw samples of all cotton stored and mark the grade on each bale so that the warehouse company can guarantee the grade of all cotton stored.

The Division of Markets will coöperate with the Office of Markets, United States Department of Agriculture, in every possible way to secure the enforcement of the Federal Warehouse Bill which has been enacted by Congress. If a warehouse is bonded and licensed by the Federal Government according to the terms of this act, and the value of the cotton is established through an official State grader, then the warehouse company is prepared to issue a uniform warehouse receipt of unquestioned value which should be negotiable in any place in the United States. Farmers should be able to borrow money at 6 per cent or less and store their cotton until prices are good. Thus the crop will be distributed more evenly throughout the year, depression of prices early in the season will be avoided, fluctuation in price will be less violent, and there will be less cotton for speculators to manipulate.

Any organization whose farmers have their cotton graded by a licensed State grader and stored in a licensed bonded warehouse is prepared to guarantee the grade of its cotton and can readily classify it in large lots of a given grade and staple and sell it by grade in the market that will pay the best price for it. In the survey of the cotton mills of the State one hundred and thirty-one mills stated that they would be interested in receiving offers of cotton from responsible organizations of producers whose cotton has been graded and classed by a State or Federal grader. Forms of by-laws for incorporating coöperative warehouse companies and cotton-marketing associations have been worked out and will be furnished upon request.

ORGANIZATION FOR CREDIT.

During the last year this Division organized ten credit unions for short-time credit as authorized by the North Carolina Legislature in the spring of 1915, and has helped in the organization of sixty National Farm Loan Associations for long-time loans. To promote these organizations, two extension circulars were published, one (Circular 13) entitled "North Carolina Credit Unions" and the other (Circular 14) entitled "The Federal Farm Loan Act." Besides, many shorter articles have

been written and published in various publications or distributed from this office.

The Farm Loan Act meets such a manifest need that organization under it has been largely made possible through correspondence and the distribution of Form 100 for individual application for Loan and Extension Circular 14. This Division has held twenty-two meetings and the demonstration agents many others to help farmers to understand the Federal Farm Loan Act. The amount of loans applied for up to October 24th (the date of the meeting of the Federal Farm Loan Board in Raleigh) was $2,049,150, and sixteen days later over a million more was applied for, making a total by November 9th of $3,060,900.

The credit unions require more coöperation on the part of farmers, and so more attention on our part to get them started and to insure their success. From three to five meetings are necessary to organize a credit union, while the farmers may get together by themselves and form a National farm loan association. Over 50 per cent of the money of a credit union comes from members, while 100 per cent of the funds for a National farm loan association is obtained by the issue of bonds.

The credit unions under State regulations are, however, for a wider range of purposes than the National farm loan association. These purposes are in brief:

1. They encourage saving on the part of men, women, and children by paying 4 per cent on deposits and 6 per cent on stock.

2. They lend funds to members for productive purposes, for one month to a year, at 6 per cent interest.

3. They enable members to purchase coöperatively farm supplies in large amounts for cash and to save the members the high cost of supply store credit.

4. They are able to get funds from banks at a cheaper rate and on better terms than can the individual farmer.

5. They keep the funds of the country in the country for the development of country enterprise.

6. Finally, they develop coöperation among farmers and inspire confidence. That the German farmers, on an average, deposit over $10,000 in each credit union shows a confidence which the American farmer is only beginning to learn.

ACCOUNTING.

This Division is coöperating with the Division of Animal Husbandry to furnish the creameries and cheese factories of the State suitable standard forms for accounting. The object is to make possible for such association to issue a standard form of report of the business done each year. A proper system of accounting will make it possible for a business to keep track of its expenditures and for a coöperative association to keep its members informed so as to prevent misunderstandings which are so common.

Respectfully submitted,

William R. Camp,

Chief, Division of Markets and Rural Organization.

REPORT ON DRAINAGE.

To the Director:

The following report on Drainage for the year ending June 30, 1916, is given herewith.

The work of drainage investigations in North Carolina has been continued along the same general lines as in the past three years. Investigations and surveys were made in twenty different counties of the State during the year.

The work may be classified under the following headings:

1. Improvement of farm lands now under cultivation.
2. Collection of general and technical data on drainage.
3. Preliminary and reconnaissance work.

During the past year there seemed to have been a renewed interest in drainage, particularly tile drainage. There seemed to be a great deal more actual construction of tile drainage systems going on than at any other period of the work. During the four years in which the coöperative work has been carried on, from July 1, 1912, to June 30, 1916, one hundred reports have been issued, most of them accompanied by maps.

IMPROVEMENT OF FARM LANDS NOW UNDER CULTIVATION.

During the past year preliminary surveys for tile drainage systems on nineteen farms scattered over thirteen different counties and comprising a total area of about 719 acres have been made. The areas of the tracts varied in size from 2 to 200 acres. Nineteen reports, accompanied by maps, were issued of the surveys made; eight were in the Coastal Plain region and eleven in the Piedmont region of the State. Portions of the systems designed on thirteen of the farms have been staked out. In all, approximately 50,800 feet of tile have been located.

Nine farms, comprising a total area of about 250 acres, have been visited for the purpose of giving assistance in the design and construction of terraces to prevent hillside erosion. Preliminary surveys have been made on two of these farms, while the work on the other farms required no preliminary work. About 95,000 feet of terraces have been located.

COLLECTION OF GENERAL AND TECHNICAL DATA ON DRAINAGE.

The gauging stations for the determination of run-off have been continued on Toisnot Swamp Canal near Wilson, Wilson County, N. C., and on Third Creek Canal, Iredell County, N. C. The records on Third Creek are complete from March 17, 1913, to date; on Toisnot Swamp the records are complete from March 29, 1914.

In order to obtain meter readings of the flow at the station on Third Creek, Iredell County, at high stages Mr. J. P. Quinn, gauge observer at that place, was detailed in July, 1915, to take these readings. Meas-

urements of the flow have been obtained at various stages up to ten feet gauge height, and a run-off curve plotted.

Arrangements were made with the owner of the Cotton Valley Farm, Edgecombe County, to conduct experiments on two of the tile-drainage systems constructed there through two different types of soil to determine:

1. Amount of run-off on underdrained land.
2. Relation of rainfall to run-off.
3. Action of tile drains in lowering the ground water level.

PRELIMINARY EXAMINATIONS AND RECONNAISSANCE.

Three examinations of a preliminary or reconnaissance nature have been made and reports issued covering a total area of 13,600 acres. In addition, a reconnaissance survey was made of the land in the vicinity of Caw Caw Swamp and Waccamaw River in southwestern Brunswick County.

GENERAL.

Three addresses have been delivered by Mr. Lynde, as follows: One before the Conference of the North Carolina Farm Demonstration Agents, at West Raleigh, N. C., on August 23, 1915, on the general subject of "Farm Drainage"; one before the Eighth Annual Convention of the North Carolina Drainage Association on "Tile Drainage Pays," on November 30, 1915; and one before an informal meeting of the landowners along Caw Caw Swamp, Brunswick County, on January 11, 1916, on the methods to be followed in organizing a drainage district.

Two bulletins, one entitled "Farm Drainage in North Carolina," by Mr. Lynde; the other, "The Prevention and Control of Erosion, with Special Reference to Terracing," by Mr. Baker, have been published by the North Carolina Agricultural Experiment Station.

Several articles on drainage and terracing have been published in the "North Carolina Extension Farm News."

For about two months during the summer of 1915 Mr. Baker was engaged in making surveys and maps of stations in the mountains where orchard work is being carried on by the Horticultural Division and the United States Weather Bureau.

The following page gives a table showing the work done during the fiscal year ending June 30, 1916:

YEAR ENDING	TILE DRAINAGE				TERRACING				
	Preliminary Surveys	Area (Acres)	Location (Feet)	Reports	Number Farms	Preliminary Surveys	Area (Acres)	Location (Feet)	Reports
June 30, 1913	8	224	7,810	8					
June 30, 1914	18	800	24,000	11	6	4	225		2
June 30, 1915	12	1,027	28,528	*20	7	3	180	55,500	4
June 30, 1916	19	719	50,800	18	6	2	50	95,000	2
Totals	57	2,776	111,138	57	19	9	655	150,500	8

PRELIMINARY EXAMINATIONS AND REPORTS

YEAR ENDING	Swamp Reports	Area	Overflow Land Reports	Area	Total Area
June 30, 1913	4	69,000	6	22,600	91,600
June 30, 1914	8	298,300	4	4,500	302,800
June 30, 1915	3	45,800	7	15,500	61,300
June 30, 1916	2	13,400	1	200	13,600
Totals	17	426,500	18	42,800	458,400

*Preliminary surveys made in the preceding fiscal year, reports transmitted during following year. The total number reports should be same as number of surveys. There were, however, several small location tile jobs located the first year for which no report was submitted.

N. B.—Total number reports issued, most of them accompanied by maps, 4 years=100.

Respectfully submitted,

H. M. LYNDE,

Senior Drainage Engineer.

FINANCIAL REPORT

THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

in account with

The United States Appropriations, 1915-1916.

Dr.

	Hatch Fund	*Adams Fund*
To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1916, under acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906 (Adams Fund)	$ 15,000.00	$ 15,000.00

Cr.

Salaries	$ 7,232.60	$ 12,166.98
Labor	2,872.76	1,121.69
Publications	230.05	.....
Postage and stationery	217.61	85.23
Freight and express	139.64	40.25
Heat, light, water, and power	209.66	173.48
Chemicals and laboratory supplies	179.23	305.97
Seeds, plants, and sundry supplies	373.16	184.29
Fertilizers	784.21	132.27
Feeding stuffs	768.79	25.51
Library	88.08	86.84
Tools, machinery, and appliances	503.49	112.45
Furniture and fixtures	137.27	47.27
Scientific apparatus and specimens	.....	311.64
Live stock	339.56	34.80
Traveling expenses	153.89	171.33
Contingent expenses	20.00	.....
Buildings and land	750.00	.....
Total	$ 15,000.00	$ 15,000.00

THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

in account with

FARM AND MISCELLANEOUS RECEIPTS.

DR.

Receipts from other sources than the United States for the year ending June 30, 1916.....$5,065.39

Supplemental Statement.

CR.

Labor	$ 676.26	
Publications	5.34	
Postage and stationery	17.05	
Freight and express	7.81	
Heat, light, water, and power	35.14	
Chemicals and laboratory supplies	15.00	
Seeds, plants, and sundry supplies	81.87	
Fertilizers	381.44	
Feeding Stuffs	777.28	
Library	89.17	
Tools, machinery, and appliances	55.28	
Scientific apparatus and specimens	12.61	
Traveling expenses	4.95	
Contingent expenses	25.52	
Buildings and land	257.54	
Balance	2,623.13	
		$5,065.39

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1916; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $30,000, and the corresponding disbursements $30,000, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed) W. H. RAGAN,
O. L. CLARK,
C. E. THOMPSON,
Auditors.

(Seal.)

Attest: A. F. BOWEN, *Custodian.*

JULY 1915 BULLETIN 232

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE
AND THE
COLLEGE OF AGRICULTURE AND MECHANIC ARTS

RALEIGH AND WEST RALEIGH

DIVISION OF AGRONOMY

RESULTS OF VARIETY TESTS OF WHEAT, OATS AND RYE

Bulletins of the Station Will be Sent Free to Citizens of the State on Request

RALEIGH
EDWARDS & BROUGHTON PRINTING COMPANY
STATE PRINTERS AND BINDERS
1915

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE

AND THE

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

BOARD OF AGRICULTURE

*W. A. Graham, *Chairman*, Raleigh.

F. P. Latham.....Belhaven
C. W. Mitchell.....Aulander
*R. L. Woodard.....Pamlico
Clarence Poe.....Raleigh
*R. W. Scott.....Haw River
*A. T. McCallum.....Red Springs
*C. C. Wright.....Hunting Creek
William Bledsoe.....Gale
W. J. Shuford.....Hickory
A. Cannon.....Horse Shoe

BOARD OF TRUSTEES OF THE COLLEGE

Governor Locke Craig, *Chairman*.

M. B. Stickey.....Concord
T. T. Ballinger.....Tryon
W. H. Williamson.....Raleigh
O. L. Clark.....Clarkton
Everett Thompson.....Elizabeth City
R. H. Ricks.....Rocky Mount
O. Max Gardner.....Shelby
M. L. Reed.....Biltmore
*T. T. Thorne.....Rocky Mount
*C. W. Gold.....Greensboro
T. E. Vann.....Como
P. S. Boyd.....Mooresville
W. E. Daniel.....Weldon
*W. H. Ragan.....High Point
W. B. Cooper.....Wilmington
J. P. McRae.....Laurinburg

*D. H. Hill (President College), West Raleigh.

STATION STAFF

B. W. Kilgore.....Director
C. B. Williams..Vice-Director, Agronomist
W. A. Withers.....Chemist
Franklin Sherman, Jr.....Entomologist
W. N. Hutt.....Horticulturist
G. A. Roberts.....Veterinarian
[1] C. R. Hudson.....Farm Demonstration
J. P. Pillsbury.....Horticulturist
H. R. Fulton.....Plant Diseases
Z. P. Metcalf.....Entomologist
Dan T. Gray.....Animal Husbandry
W. R. Camp.....Marketing
J. M. Pickel.....Feed Chemist
W. G. Haywood.....Fertilizer Chemist
L. L. Brinkley.....Soil Survey
R. G. Hill.....Assistant Horticulturist
[2] W. E. Hearn.....Soils
R. S. Curtis, Associate in Animal Industry
J. K. Plummer.....Soil Chemist
S. C. Clapp.....Assistant Entomologist
W. H. Eaton.....Dairy Experimenter
G. M. Garren.....Plant Breeding—Cereals
[1] E. H. Mathewson.....Tobacco Expert
J. Q. Jackson.....Assistant Chemist
L. R. Detjen.....Assistant Horticulturist
A. R. Russell,
Assistant in Field Experiments
R. Y. Winters.....Plant Breeding
B. F. Kaupp,
Poultry Investigator and Pathologist
W. F. Pate.....Agronomist—Soils
E. C. Blair..Assistant Agronomist—Soils
E. S. Dewar.....Assistant Chemist
[4] H. M. Lynde.....Drainage Engineer
[1] J. M. Johnson.....Farm Management
F. R. Baker, Assistant Drainage Engineer
R. O. Cromwell, Assistant, Plant Diseases
[3] A. J. Reed.....Dairy Farming
Stanley Combes, Assistant, Dairy Farming
F. S. Peden.....Beef Cattle
[3] J. B. McVean.....Pig Clubs
[3] J. A. Arey.....Dairy Farming
[3] H. C. Ikeler.....Beef Cattle
[3] A. G. Oliver.....Poultry Clubs
Earl Hostetler,
Assistant, Beef Cattle and Swine
[3] F. R. Farnham...Asst. in Dairy Farming
[3] A. L. Jordan.....Assistant in Beef Cattle
W. C. Norton..Assistant iin Bacteriology
[1] T. E. Browne, Asst. in Charge Boys' Clubs
[1] A. K. Robertson....Asst. in Boys' Clubs
[1] Mrs. C. McKimmon,
Assistant in Charge Girls' Clubs
[1] Miss Margaret Scott,
Assistant in Girls' Clubs
E. B. Hart.....Assistant Chemist
F. E. Careuth.....Assistant Chemist
J. R. Mullen.....Assistant Chemist
F. B. Sherwood.....Assistant Chemist
B. Szymoniak,
Demonstrator in Fruit and Truck Crops
C. D. Matthews..Assistant Horticulturist
F. N. McDowell.....Soil Survey
R. W. Lieby.....Assistant Entomologist
D. T. McCarty.....Assistant Chemist
Miss Mary S. Birdsong, Sec'y to Director
A. F. Bowen.....Bursar

R. W. Collett.....Assistant Director Branch Stations
F. T. Meacham.....Assistant Director Iredell Branch Station, Statesville
J. H. Jefferies.....Assistant Director Pender Branch Station, Willard
C. E. Clark.....Assistant Director Edgecombe Branch Station, Rocky Mount
[1] E. G. Moss.....Assistant Director Granville Branch Station, Oxford
S. O. Perkins.....Assistant Director Buncombe and Transylvania Stations, Swannanoa

---

The members marked with * are members of the Joint Committee for Agricultural Work, and the Station is under their direction.

[1] In coöperation with the U. S. Department of Agriculture, Bureau of Plant Industry.
[2] In coöperation with the U. S. Department of Agriculture, Bureau of Soils.
[3] In coöperation with U. S. Department of Agriculture, Bureau of Animal Industry.
[4] In coöperation with the U. S. Department of Agriculture, Office of Experiment Stations.

RESULTS OF VARIETY TESTS OF WHEAT, OATS AND RYE

By G. M. Garren, Agronomist in Cereal Investigations.

There are a large number of varieties of small grains and this number is frequently augmented by a mere change in the name of some variety that has already been established. The same variety may be known in one locality by one name, and in another locality by an entirely different name. This tends to confuse. Then among the true varieties all are not equally well adapted to the same soil types and the same climatic conditions. Usually one or two of the varieties will out-yield the others on some particular soil type and under certain climatic conditions. To distinguish true varieties and to discover the varieties best adapted to the soil and climate of a given locality is the object of a variety test.

Variety tests of wheat, oats, and rye are being conducted on the Buncombe, Iredell, and Central Station farms. The soil and climate of these farms are fairly representative of the small grain growing sections of the State. A variety that proves its worth in a test on the Buncombe farm would doubtless be a good variety for all western North Caolina. Again, a superior variety in the tests on the Iredell farm would likely prove a good variety anywhere on the Cecil clays of the Piedmont section. The Central Station farm, near Raleigh, is representative of the lower Piedmont section. Small grain growing in the lower Coastal Plain section of the State is not practiced to any great extent except with oats and rye.

The results of the tests at each of the above farms during the past three years are embodied in the tables that follow. (The tables are arranged and discussed under the general heading of the farm where conducted.) In the arrangement the convenience of those interested only in the higher yielding varieties has been provided for. The first column of the table gives the rank of the varieties, the second and largest column of the table gives their names, and the last column gives their relative yields per acre, upon which the ranking is based. Those interested in the more minute details will find the information under the proper headings in the other columns of the tables. In the discussions the wearisome repetition of minute details has been avoided and attention called to only the outstanding features of the tests.

The Bureau of Plant Industry of the U. S. Department of Agriculture has furnished the seed of many of the varieties tested. These varieties are numbered with the initials "B. P. I." following the number.

The seed for the other varieties was secured from the originators, seedsmen, and from other sources. For the past two years home-grown seed from the test plats have been saved for reseeding, and these seed

TABLE I—WHEAT VARIETY TEST—BUNCOMBE FARM 1912.

Rank According to Yield Per Acre	Varieties	Date of Maturity	B=Bearded S=Smooth	Yield Per Plat		Yielding Capacity		Yield Per Acre	
				Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain	Pounds of Straw	Bushels of Grain
1	Red May	6-20	S	39.0	29.0	57.4	42.6	1174	14.5
2	Fulcaster	6-25	B	32.5	25.5	56.0	44.0	978	12.8
3	Minch	6-27	B	32.5	25.0	56.5	43.5	978	12.5
4	Dietz-Mediterranean	6-26	B	28.5	23.5	54.9	45.1	858	11.8
5	A local selection	6-25	S	29.0	23.0	55.8	44.2	873	11.5
6	Lancaster*	6-25	B	32.5	22.5	59.5	40.5	978	11.3
7	Purple Straw	6-25	S	28.0	22.0	56.0	44.0	843	11.0
7	Lancaster*	6-25	B	27.0	22.0	55.1	44.9	813	11.0
8	Leap's Prolific*	6-24	S	28.0	21.0	57.1	42.9	843	10.5
8	Miller's Choice*	6-27	B	29.0	21.0	58.0	42.0	873	10.5
9	Fultz	6-25	S	25.5	20.5	55.6	44.4	768	10.3
9	A local selection	6-27	S	25.5	20.5	55.6	44.4	768	10.3
9	Leap's Prolific (seed home grown)	6-25	S	23.5	20.5	53.4	46.6	707	10.3
10	A local selection	6-25	B	22.5	20.0	52.9	47.1	677	10.0
11	Red Wonder	6-26	B	33.5	18.5	64.4	35.6	1009	9.3
11	Australian Red	6-25	B	37.5	18.5	67.0	33.0	1129	9.3
12	Graham's Choice	6-27	S	21.0	18.0	53.8	46.2	632	9.0
13	Miller's Choice	6-27	B	22.5	17.0	57.1	42.9	677	8.5
14	Klondyke	6-30	S	18.0	13.5	57.1	42.9	542	6.8
15	Acme	6-30	B	21.0	10.5	66.7	33.3	632	5.3

*Seed secured away from Test Farm.

have been sown along with seed from original sources for purposes of comparison.

Tables of compiled results and other tables of minor experiments are given below and discussed in their proper places.

Varieties of Wheat at the Buncombe Test Farm.

In Table 1 are reported the results of the test on the Porter's loam type of soil of the Buncombe Test Farm in 1912. Twenty varieties of wheat were tested and of this number eleven were of the bearded varieties and nine smooth. The eleven bearded varieties averaged 10.2 bushels per acre; the nine smooth varieties averaged 10.5 bushels—only 0.3 of a bushel per acre on the average in favor of the smooth wheats. This is too small an amount to warrant a conclusion. Three of the varieties were sown in duplicate—one plat with home-grown seed, the other with imported seed. The three from home-grown seed averaged 9.9 bushels per acre, the three from imported seed 10.8 bushels—a difference of 0.9 of a bushel in favor of the imported seed. Red May and Fulcaster are the two highest yielders; Klondyke and Acme the two lowest. The weight of a measured bushel of grain was assumed to be 60 pounds with all the varieties. The plats were .033 acre in size. The grain was harvested on June 30.

In Table 2 is recorded the results of the test on the Buncombe farm in 1913. Again Red May leads. Leap's Prolific and Fulcaster come second with equal yields. Fultz (seed home-grown) and Fultz (seed shipped in), and Dietz Mediterranean made the lowest yields. Nineteen varieties, eighteen wheat and one rye, were tested. Eight of the wheats were bearded, ten smooth. The bearded averaged 10.1 bushels; the smooth 10.4 bushels—a difference of 0.3 of a bushel in favor of the smooth wheats. Five of the varieties were sown in duplicate from home-grown and imported seed. The five from home-grown seed average 9.8 bushels; the five from imported seed 10.2 bushels—a difference of 0.4 of a bushel in favor of the imported seed. The varieties in the test this year were grown on .031 acre plate. They were seeded on October 3 and harvested on June 26. Sixty pounds was the weight assumed for a measured bushel for all varieties.

Table 3 gives the results secured in tests at the Buncombe Farm in 1914. Eight varieties of wheat were sown in duplicate from home-grown and imported seed. Two of rye were also sown. Fultz and Dietz-Mediterranean, producing equal yields, take first rank. Leap's Prolific and Martin's Amber take second and third places respectively. All four of these highest yielders were sown from home-grown seed. The six lowest yielders were grown from imported seed. In this test, the eight varieties from home-grown seed averaged 20.7 bushels; the eight from imported seed 14.9 bushels—a difference of 5.8 bushels in favor of the home-grown seed. Four of the varieties were bearded, four were,

TABLE II—WHEAT AND RYE VARIETY TÉST— BUNCOMBE FARM 1913.

Rank According to Yield Per Acre	Varieties	B—Bearded S—Smooth	Yield Per Plat		Yielding Capacity		Yield Per Acre	
			Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain	Pounds of Straw	Bushels of Grain
1	Red May	S	27.0	15.0	64.3	35.7	1312	12.7
2	Leap's Prolific*	S	34.0	22.0	60.7	39.3	1086	11.7
2	Fulcaster (seed imported)	B	35.5	22.0	61.7	38.3	1134	11.7
3	Poole (B. P. I. No. 1979)	S	35.5	21.5	62.3	37.7	1134	11.4
4	Miller's Choice (seed home grown)	B	31.5	21.0	60.0	40.0	1007	11.2
5	Fultz-Mediterranean (B. P. I. No. 1957)	S	35.5	20.5	63.4	36.6	1135	10.9
5	Martin's Amber (B. P. I. No. 1974)	S	33.5	20.5	62.0	38.0	1071	10.9
6	Miller's Choice*	B	32.0	20.0	61.5	38.5	1022	10.6
7	Stoner-Miracle (B. P. I. No. 2980)	B	29.0	19.0	60.4	39.6	927	10.1
7	Fultz (B. P. I. No. 1923)	S	29.0	19.0	60.4	39.6	927	10.1
7	Virginia (B. P. I. No. 3277)	B	34.0	19.0	64.2	35.8	1087	10.1
7	Dietz-Mediterranean (seed home grown)	B	31.0	19.0	62.0	38.0	991	10.1
8	Leap's Prolific (seed home grown)	S	30.5	18.5	62.2	37.8	975	9.8
9	Klondyke	S	30.0	18.0	62.5	37.5	959	9.57
10	Fulcaster (seed home grown)	B	32.0	17.5	64.6	35.4	1022	9.3
11	Fultz (seed home grown)	S	28.5	16.5	63.3	36.7	911	8.77
11	Fultz (seed imported)	S	25.5	16.5	60.7	39.3	815	8.77
12	Dietz-Mediterranean*	B	27.0	16.0	62.8	37.2	863	8.5
1	Common Rye	B	77.0	22.0	77.8	22.2	2460	12.5

*Seed secured away from Test Farm.

TABLE III.—WHEAT AND RYE TEST—BUNCOMBE FARM 1914.

Rank According to Yield Per Acre	Varieties	B—Bearded S—Smooth	Yield Per Plat		Yielding Capacity		Weight, Measured Bushels of Grain	Yield Per Acre	
			Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain		Pounds of Straw	Bushels of Grain
1	Fultz (seed home grown)	S	32.5	27.5	54.2	45.8	54	1539	24.1
1	Dietz-Mediterranean (seed home grown	B	29.5	24.5	54.6	45.4	48	1397	24.2
2	Leap's Prolific (seed home grown)	S	31.5	26.5	54.3	45.7	53	1491	23.6
3	Martin's Amber (B. P. I. No. 1974) (seed home grown)	S	28.5	23.5	54.8	45.2	52	1349	21.4
4	Fulcaster (seed imported)	B	30.0	22.0	57.7	42.3	52	1420	20.0
5	Stoner-Miracle (B. P. I. No. 2980) (seed home grown)	B	24.5	21.5	53.3	46.7	53	1160	19.2
6	Poole (B. P. I. No. 1979) (seed home grown	S	32.5	21.5	60.2	39.8	54	1539	18.8
7	Virginia (B. P. I. No. 3277 (seed home grown)	B	33.0	19.0	63.5	36.5	51	1563	17.6
8	Fulcaster (seed home grown)	B	23.5	18.0	56.6	43.4	50	1113	17.0
9	Poole (B. P. I. No. 1979)*	S	25.5	18.5	58.0	42.0	52	1207	16.8
10	Dietz-Mediterranean*	B	23.5	17.5	57.3	42.7	53	1113	15.6
11	Fultz (seed imported)	S	24.5	16.5	59.8	40.2	53	1964	14.7
12	Stoner-Miracle (B. P. I. No. 2980)*	B	23.0	14.0	62.2	37.8	51	1089	13.0
13	Leap's Prolific*	S	22.0	13.0	62.9	37.1	50	1042	12.3
14	Virginia (B. P. I. No. 3277)*	B	23.0	13.0	63.9	36.1	52	1089	11.8
15	Martin's Amber (B. P. I. No. 1974)*		36.5	11.5	76.0	24.0	54	1728	10.1
1	Abruzzi Rye	B	28.0	16.0	63.6	36.4	50	1326	15.1
2	Common Rye	B	23.5	13.5	63.6	36.4	44	1113	14.5

*Seed secured away from Test Farm.

smooth. The four bearded varieties from the home-grown seed averaged 19.4 bushels; the four smooth 21.9 bushels—a difference of 2.5 bushels in this instance in favor of the smooth wheats. A like comparison for all the varieties, both bearded and beardless, from the imported seed gives a difference of 0.3 bushel in favor of the bearded wheats. The eight seedings of bearded wheat produced an average yield of 17.2 bushels; and the eight smooth an average of 18.3 bushels—a difference of 1.1 bushels in favor of the beardless wheats. The plats on this farm this year were only .021 an acre. The varieties were seeded on October 7 and harvested June 27 of the following year.

Table 4 records the compiled results of the variety tests of wheat at the Buncombe farm for the past four years—for the three years under consideration and one previous year. Unfortunately, there have been but four varieties common to these tests. Compiled results for the four years are far more reliable than a single year's test. In compiling this short table the yields from the home-grown seed were used. Leap's Prolific leads Dietz-Mediterranean by a small fraction of a bushel. It excels Futz by 2.2 bushels and Fulcaster by 2.6 bushels per acre. This increase in the yield in a large field would amount to quite an item. A variety that maintains its lead in a four-year test has demonstrated its superiority over its competitors. Two of these varieties are bearded and two are smooth. The average yield of the smooth varieties excels that of the bearded by only 0.4 of a bushel per acre.

Results at Blantyre in 1914.

In 1914, a variety test of wheat was conducted at Blantyre, in Transylvania County. The wheat was sown on Toxaway loam of the French Broad River bottoms, a type of soil that is generally considered by farmers to be poorly adapted to wheat growing.

These results are incorporated for their suggestive value, rather than as final results, for one year's results on any type of soil is not considered as conveying very definite information. Some of these yields are fair in comparison with the yields secured at the Buncombe farm. No one, however, can profitably grow wheat that does not yield over 5.8, 6.3, or 8 bushels per acre. This is what the lowest yields were in this test, as will be observed from the results given in Table 5. One-thirtieth of an acre was the size of the plats. A measured bushel in all instances was assumed to be sixty pounds.

Varieties of Wheat at the Iredell Farm.

The Iredell Test Farm is situated near the center of the wheat-growing region of North Carolina. Iredell County belongs to that group of counties of the State that excel in wheat production. The type of soil is the Cecil clay, a type especially adapted to wheat growing.

TABLE IV—COMPILED RESULTS OF VARIETY TEST OF WHEAT—BUNCOMBE FARM—YIELD PER ACRE.

Rank According to Average Yield Per Acre	Varieties	1911		1912		1913		1914		Averages	
		Pounds of Straw	Bushels of Grain	Pounds of Straw	Bushels of Grain	Pounds of Straw	Bushels of Grain	Pounds of Straw	Bushels of Grain	Pounds of Straw	Bushels of Grain
1	Leap's Prolific	1740	23.3	707	10.2	974	9.8	1491	23.6	1228	16.7
2	Dietz-Mediterranean	1640	20.0	858	11.7	990	10.1	1396	24.1	1221	16.4
3	Fultz	1280	15.0	768	10.2	910	8.7	1538	24.1	1224	14.5
4	Fulcaster	1880	18.0	978	12.8	1022	9.3	1112	17.0	1248	14.2

TABLE V— VARIETY WHEAT AND RYE TEST—BLANTYRE FARM 1914.

Rank According to Yield Per Acre	Varieties	B=Bearded S=Smooth	Yield Per Plat		Yielding Capacity		Yield Per Acre	
			Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain	Pounds of Straw	Bushels of Grain
1	Leap's Prolific	S	27.5	24.5	52.9	47.1	825	12.3
2	Fultz-Mediterranean (B. P. I. No. 1980)	S	30.5	24.0	56.0	44.0	916	12.0
3	Martin's Amber (B. P. I. No. 1974)	S	41.0	23.5	63.6	36.4	1230	11.8
4	Lancaster	B	25.0	22.5	52.6	47.4	750	11.3
5	Fulcaster	B	28.0	22.0	56.0	44.0	840	11.0
5	Stoner-Miracle (B. P. I. No. 2980)	B	30.0	22.0	57.7	42.3	900	11.0
5	Poole (B. P. I. No. 1979)	S	26.0	22.0	54.2	45.8	780	11.0
6	Golden Chaff	S	26.5	21.5	55.2	44.8	795	10.8
7	Fultz (B. P. I. No. 1923)	S	30.0	21.0	58.8	41.2	900	10.5
8	Purple Straw	S	24.5	19.5	55.7	44.3	735	9.8
9	Stoner-Miracle	B	23.0	18.5	55.4	44.6	690	9.3
10	Dietz-Mediterranean	B	27.5	17.5	61.1	38.9	825	8.8
11	Virginia (B. P. I. No. 3277)	B	26.0	16.5	61.2	38.8	780	8.3
12	Red Wonder	B	23.0	16.0	59.0	41.0	690	8.0
13	Fultz	S	19.5	12.5	60.9	39.1	585	6.3
14	Harvest King	S	20.0	11.5	63.5	36.5	600	5.8
1	Common Rye	B	35.5	19.5	64.5	35.5	1065	9.8

In Table 6 are recorded the results of the test on the Iredell farm in 1912. Twenty varieties were tested, eleven bearded, eight smooth, and one unknown. Several of them are doubtless mere name-varieties. Shoaf's, perhaps one of the old standard varieties "with a local habitation and a name," ranks first. It had the advantage of being acclimatized. Leap's Prolific takes second place. One and one-tenth bushels is the difference in yield in favor of the bearded wheats. The local varieties were not contintinued in the tests after this year. The plats were one-twentieth of an acre in size and were seeded to wheat on November 11 and harvested on June 2. The weights of a measured bushel were assumed to be 60 pounds for all the varieties.

Table 7 contains the records of the results obtained on this farm in 1913. Twenty-two varieties were tested, of which twelve were bearded and ten were smooth. The bearded wheats averaged 17.4 bushels; the smooth 18.2. The smooth wheats excelled by 0.8 of a bushel per acre. Leap's Prolific and Beardless Fulcaster, having the same yield, jointly took first rank. Dietz-Mediterranean and Miller's Choice, usually two good yielding varieties, ranked lowest in this test. The rank of a particular variety in a test will vary from year to year. Only the average yield for a number of years will accurately determine a variety's true value for any particular section. The seeding was made on October 30 and the harvesting on June 17. The plats on this farm were one-twentieth of an acre in size.

In Table 8 are recorded the results of the test on the Iredell farm in 1914. Thirteen varieties, seven bearded and six smooth, were tested during this year. Fultz was included twice, in one case the seed being furnished by the Bureau of Plant Industry and in the other by the local farm. Six of the bearded and the six smooth-headed varieties were sown in duplicate plats from home-grown seed and from imported seed. With the bearded varieties, the six sown from home-grown seed averaged 13.7 bushels and the six from imported seed 13.3 bushels. This gives 0.4 of a bushel in favor of the home-grown seed. With the smooth varieties, the six from home-grown seed averaged 14.8 bushels, while the six from imported seed yielded 14.3 bushels per acre. This is just one-half bushel in favor of the home-grown seed. The thirteen bearded wheats averaged 13.4 bushels while the twelve smooth yielded 14.9 bushels. Here the smooth wheats excel the bearded by one and a half bushels per acre. The varieties this year were seeded on November 4 and harvested on June 20, following.

The actual weight of a measured bushel of wheat is an important item. The heavier the seed of a wheat, other things being equal, the more valuable the variety. In Table 8 there is no great difference between the weights of a measured bushel from home-grown seed and from imported seed of the same variety, but there is a marked variation in the weight of the seed of some of the varieties. The weight of a measured bushel of Poole from both the home-grown and the imported seed

TABLE VI—VARIETY WHEAT TEST—IREDELL FARM 1912.

Rank According to Yield Per Acre	Varieties	B=Bearded S=Smooth	Yield Per Plat		Yielding Capacity		Yield Per Acre	
			Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain	Pounds of Straw	Bushels of Grain
1	Shoaf's	B	74.25	45.75	61.9	38.1	1485	15.25
2	Leap's Prolific	S	60.50	44.50	57.6	42.4	1210	14.83
3	Australian Red	B	64.00	41.00	61.0	39.0	1280	13.67
4	Fulcaster	B	71.00	39.00	64.5	35.5	1420	13.00
5	Red May	S	73.00	37.00	66.4	33.6	1460	12.33
6	Lancaster	B	73.75	36.25	67.0	33.0	1475	12.08
7	Fulcaster	B	74.00	36.00	67.3	32.7	1480	12.00
8	Miller's Choice	B	66.50	33.50	66.5	33.5	1330	11.17
9	Young's Prolific	S	63.50	31.50	66.8	33.2	1270	10.50
10	J. S. Carr's		70.00	30.00	70.0	30.0	1400	10.00
11	Unknown	B	60.75	29.25	67.5	32.5	1215	9.75
12	Minch	B	76.75	28.25	73.1	26.9	1535	9.42
13	Golden Chaff	S	67.50	27.50	71.1	28.9	1350	9.17
14	Graham's Choice	S	53.75	26.25	67.2	32.8	1075	8.75
15	Dietz-Mediterranean	B	77.00	23.00	77.0	23.0	1540	7.67
16	Purple Straw	S	107.75	22.25	82.9	17.1	2155	7.42
17	Fultz	S	74.00	21.00	77.9	22.1	1480	7.00
18	Acme	B	50.25	19.75	71.8	28.2	1005	6.58
19	Klondyke	S	70.75	14.25	83.2	16.8	1415	4.75
20	Red Wonder	B	101.00	14.00	87.8	12.2	2020	4.67

TABLE VII—WHEAT VARIETY TEST—IREDELL FARM 1913.

Rank According to Yield Per Acre	Varieties	B—Bearded S—Smooth	Yield Per Plat		Yielding Capactiy		Weight, Measured Bushels of Grain	Yield Per Acre	
			Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain		Pounds of Straw	Bushels of Grain
1	Leap's Prolific	S	95.5	59.0	61.9	38.1	60.00	1910	19.67
1	Beardless Fulcaster	S	103.0	59.0	63.6	36.4	60.00	2060	19.67
2	Virginia (B. P. I. No. 3277)	B	94.0	59.0	61.4	38.6	60.75	1880	19.42
3	Poole (B. P. I. No. 1979)	S	102.0	58.0	63.8	36.2	60.00	2040	19.33
4	B. P. I. No. 3610	S	86.0	58.0	59.7	40.3	60.50	1720	19.17
5	Purple Straw	S	108.0	57.0	65.5	34.5	60.00	2160	19.00
6	Red Wonder	B	106.5	57.5	64.9	35.1	60.75	2130	18.93
7	Australian Red	B	101.0	57.0	63.9	36.1	60.50	2020	18.84
8	Fultz	S	82.0	56.0	59.5	40.5	60.00	1640	18.67
9	Stoner-Miracle (B. P. I. No. 2980)	B	111.0	55.0	66.9	33.1	60.25	2220	18.25
10	Lancaster	B	109.0	54.0	66.9	33.1	60.50	2180	17.85
11	Virginia (B. P. I. No. 3277)	B	99.5	53.5	65.0	35.0	60.50	1990	17.69
12	Eden Wheat	B	112.0	53.0	67.9	32.1	60.75	2240	17.45
13	Mediterranean-Fultz (B. P. I. No. 1957)	S	105.0	52.0	66.9	33.1	60.25	2100	17.26
14	Martin's Amber (B. P. I. No. 1974)	S	94.5	52.0	64.5	35.5	60.50	1890	17.19
15	B. P. I. No. 3611	B	109.0	50.0	68.6	31.4	60.00	2180	16.67
16	Red May	S	83.0	50.0	62.4	37.6	60.50	1660	16.53
17	B. P. I. No. 3614	B	110.0	49.0	69.2	30.8	60.50	2200	16.20
18	Fulcaster	B	98.5	49.0	66.8	33.2	60.75	1970	16.13
19	Fultz (B. P. I. No. 1923)	S	84.5	48.0	63.8	36.2	60.00	1690	16.00
20	Dietz-Mediterranean	B	95.0	48.0	66.4	33.6	60.50	1900	15.86
21	Miller's Choice	B	90.5	46.5	66.5	33.5	60.00	1810	15.50

TABLE VIII—VARIETY TEST OF WHEAT—IREDELL FARM 1914.

Rank According to Yield Per Acre	Varieties	B=Bearded S=Smooth	Yield Per Plat		Yielding Capacity		Weight, Measured Bushel of Grain	Yield Per Acre	
			Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain		Pounds of Straw	Bushels of Grain
1	Poole (B. P. I. No. 1974)*	S	93.0	52.0	64.1	35.9	52	1860	20.0
2	Leap's Prolific (seed home grown)	S	93.0	52.0	64.1	35.9	62	1860	16.8
3	Purple Straw (seed home grown)	S	73.5	51.5	58.8	41.2	62	1470	16.6
4	Stoner-Miracle (B. P. I. No. 2980) (seed home grown)	B	98.0	47.0	67.6	32.4	59	1960	15.9
5	Poole (B. P. I. No. 1974) (seed home grown)	S	79.0	41.0	65.8	34.2	52	1580	15.8
6	Leap's Prolific*	S	83.5	46.5	64.2	35.8	60	1670	15.5
7	Fultz (B. P. I. No. 1973)*	S	82.5	42.5	66.0	34.0	55	1650	15.5
8	Martin's Amber (seed home grown)	S	105.0	40.0	72.4	27.6	52	2100	15.4
9	Stoner-Miracle (B. P. I. No. 2980)*	B	90.0	45.0	66.7	33.3	59	1800	15.3
10	Fultz (B. P. I. No. 1923) (seed home grown)	S	80.5	44.5	64.4	35.6	60	1610	14.9
11	Fulcaster (seed home grown)	B	89.5	44.5	64.4	35.6	62	1610	14.4
12	Fulcaster*	B	103.0	42.0	71.1	28.9	59	2060	14.2
13	Dietz-Mediterranean (seed home grown)	B	87.0	43.0	66.9	33.1	61	1740	14.1
13	Lancaster (seed home grown)	B	83.0	42.0	66.4	33.6	60	1660	14.0
14	Dietz-Mediterranean*	B	78.5	41.5	65.4	34.6	60	1570	13.8
15	Red Wonder (seed home grown)	B	112.5	42.5	72.6	27.4	62	2250	13.7
16	Purple Straw*	S	95.0	40.0	70.4	29.6	60	1900	13.3
17	Lancaster*	B	76.0	39.0	66.1	33.9	61	1520	12.8
18	Red Wonder*	B	106.0	39.0	73.1	26.9	62	2120	12.6
19	Eden Wheat	B	98.5	36.5	73.0	27.0	59	1970	12.4
20	Martin's Amber*	S	88.5	31.5	73.8	26.2	53	1770	11.9
21	Virginia (B. P. I. No. 3277)*	B	75.5	34.5	68.6	31.4	59	1510	11.7
22	Virginia (B. P. I. No. 3277) (seed home grown)	B	73.0	32.0	69.5	30.5	60	1460	10.7
23	Fultz*	S	50.0	30.0	62.5	37.5	59	1000	10.2
24	Fultz (seed home grown)	S	45.0	25.0	64.3	35.7	52	900	9.6

*Seed secured away from Test Farm.

is 52 pounds—8 pounds below commercial standard. Leap's Prolific weighs 62 pounds for the imported, 60 for the home-grown seed—an average of 61 pounds—one pound above commercial standard. This is a difference of 9 pounds per bushel between these two varieties. The yields being equal or nearly so, the heavier wheat is the superior. The determination of the average weight of a measured bushel of wheat for a series of years is important, as is the average yield, in determining the superiority of a variety.

Table 9 embraces the compiled results for seven varieties in the tests at the Iredell farm for the past five years. The time includes the three years now under consideration and two previous years. Leap's Prolific and Lancaster have equal ratings, having an average yield of 18 bushels each for the past five consecutive years. There is only one-tenth of a bushel difference, however, between the yields of these and the yield of Fulcaster. Disregarding this small difference, these three varieties have practically the same rating. There is, however, a difference in yield ranging from 1.1 to 1.8 bushels between these and the four remaining varieties. When the average yield of one variety for so long a time equals or exceeds a bushel more than the yield of another variety, it proves its superiority, for an increase of one bushel per acre in the yield from a large acreage would materially increase the profits from a wheat crop. When this difference amounts to 1.8 bushels, the profits would be very materially increased. Three of these are smooth-headed and four are bearded varieties. The smooth ones average 16.9 and the bearded ones 17.2 bushels. This is a difference of 0.3 bushel in favor of the bearded wheats. These results are of especial interest to any wheat grower whose farm is located in the Piedmont section of the State.

SEEDING TESTS WITH WHEAT.

In 1913 and 1914 experiments were conducted on the Iredell farm to determine the best date for seeding wheat in that portion of the State. The treatment of the plats was identical in preparation, in fertilization, and in the amount and the variety of seed sown. The scheme called for the seeding of a plat every two weeks unless prevented by unfavorable weather conditions. None were sown extremely early, but the last seedings were quite late, as sowing too late rather than too early is more frequently the practice with wheat farms in North Carolina. To throw light on this practice and to correct it, if possible, was the main purpose of the experiments.

The weights of the straw and the grain from each plat, but not the weights of a measured bushel of grain, were obtained. The standard weight of 60 pounds per bushel was used in calculating the yield per acre from each plat.

In Table 10 are recorded the results of the seeding test experiment conducted in 1913. Ninety-four pounds per plat, or 31.3 bushels per

TABLE IX—COMPILED RESULTS OF VARIETY TESTS OF WHEAT—REDELL FARM—YIELD PER ACRE.

Rank According to Average Yield Per Acre	Varieties	1910		1911		1912		1913		1914		Averages	
		Pounds of Straw	Bushels of Grain	Pounds of Straw	Bushels of Grain	Pounds of Straw	Bushels of Grain	Pounds of Straw	Bushels of Grain	Pounds of Straw	Bushels of Grain	Pounds of Straw	Bushels of Grain
1	Leap's Prolific	955	19.0	1580	20.3	1210	14.8	1910	19.6	1860	16.7	1503	18.0
1	Lancaster	1990	23.5	2230	23.0	1475	12.0	2180	17.8	1060	14.0	1907	18.0
2	Fulcaster	1530	26.1	1720	20.0	1420	13.0	1970	16.1	1610	14.3	1650	17.9
3	Dietz-Mediterranean	1980	25.3	2070	22.1	1540	7.6	1900	15.8	1740	14.0	1846	16.9
4	Purple Straw	1740	21.0	1480	18.6	2155	7.4	2160	19.0	1470	16.6	1801	16.5
5	Fultz	1000	21.5	1135	20.0	1480	7.0	1640	18.6	1610	14.8	1383	16.3
6	Red Wonder	1570	25.5	1390	18.3	2020	4.6	2130	18.9	2250	13.7	1872	16.2

TABLE X—DIFFERENT DATES OF SEEDING WHEAT—IREDELL FARM 1913.

Dates—1912	Yield Per Plat		Yield Per Acre	
	Pounds of Straw	Pounds of Grain	Pounds of Straw	Bushels of Grain
October 10	166	94	3320	31.3
October 28	131	81	2620	27.0
November 9	108	71	2160	23.6
November 23	87	68	1740	22.6
December 7	80	65	1600	21.6
December 21	63	52	1260	17.3

acre, was the yield for the first seeding, made on October 10. A seeding two weeks later reduced the yield 13 pounds per plat, or 4.3 bushels per acre. There was a loss of ten pounds between the next two dates—October 28 and November 9. Between November 9, November 23, and December 7, there was a difference of only three pounds for each date. Three pounds per plat, equal to one bushel per acre, would amount to 100 bushels for a hundred-acre field. From this it can be seen that it is better to sow on November 9 and save this hundred bushels than to sow on November 23 and lose it. Better sow on November 9 and save 200 bushels than sow on December 7 and lose it. But the greatest contrast is shown in the yields of the first seeding of October 10 and the last seeding of December 21. The difference between the yields of these seedings was 42 pounds per plat, 14 bushels per acre, more than the average yield of wheat for the State. Yet there is wheat sown in North Carolina as late as December 21. The yields of straw decreased to a greater extent from the early sowings to the late than did the yields of grain. The yield of straw from the December 21 seeding was only 37.9 per cent of the yield obtained from the plat sown on October 10, while the yield of grain was 55.3 per cent of the October 10 seeding. In this instance, sowing a wheat crop on December 21 rather than on October 10 reduced the yield 44.7 per cent or nearly one-half.

In Table 11 are the results of the experiment in 1914. The scheme was the same as in 1913. In this experiment the early October sowing was omitted and the later one was delayed a week. Therefore only one week instead of two intervened between the first and second seedings. Yet this short difference in time of sowing made a differenc in yield of 9 pounds to the plat, 3 bushels to the acre, or 150 bushels to a fifty-acre field in favor of the earlier seeding. Between the seedings of November 1 and November 15 there is a difference in yield per plat of only one-half pound. Between the earliest and latest seedings there was a difference in yield of 36 pounds per plat, equivalent to 12 bushels per acre, a little more than the average yield of the State, which is 11.7 bushels. The

TABLE XI—DIFFERENT DATES OF SEEDING WHEAT—IREDELL FARM 1914.

Dates—1913	Yield Per Plat		Yield Per Acre	
	Pounds of Straw	Pounds of Grain	Pounds of Straw	Bushels of Grain
October 25	154	71	3080	23.6
November 1	163	62	3260	20.6
November 15	123.5	61.5	2470	20.5
November 29	98	52	1960	17.3
December 13	75	35	1500	11.6

difference in yield of straw between the wheat seeded at these dates was 1,580 pounds. Again, in this instance, the crop sown on December 13 was 50.7 per cent less than that secured from the crop sown on October 25.

Varieties of Oats at Iredell Farm.

Two tests of oat varieties have been conducted on the Iredell farm in the past three years. The test in 1912 was winter-killed. The results of the test conducted in 1913 are embodied in Table 12, fifteen varieties being tested. The Appler variety in three strains takes the three first places for highest yield. The weights of a measured bushel for all the varieties are fairly uniform, none being very low. The Golden Giant Side variety is lowest. A bushel of this variety weighed 30 pounds—2 pounds below standard. A bushel of Virginia Turf weighed 34 pounds—2 pounds above standard. B. P. I. No. 511 weighed 35 pounds to the measured bushel—3 pounds above standard. This latter variety had been improved in the breeding plats of the Bureau of Plant Industry, which doubtless explains its improvement in weight of grain. All the varieties were seeded on October 11.

The results of the oat variety test on the Iredell farm in 1914 are recorded in Table 13, seven varieties being tested. In yield, Fulghum takes first rank, Appler and Burt jointly take second rank, and Virginia Turf is last. This latter variety ranked eleven in the test of fifteen varieties in 1913. The early part of the season of 1914 was extremely dry, and hence was very unfavorable for oat growth. Fulghum did remarkably well under these circumstances. It seemed in this particular test to possess drought resisting qualities in an unusual degree. The weight of a measured bushel for the year was far below standard in every case. The grain was not well developed on account of the extremely dry season. Fulghum was the heaviest, yet it was 3 pounds below standard. Burt and Virginia Turf were each 10 pounds below. This test was seeded on November 4.

TABLE XII—OAT VARIETY TEST—IREDELL FARM 1913.

Rank According to Yield Per Acre	Varieties	Yield Per Plat		Yielding Capacity		Weight Measured Bushel of Grain	Yield Per Acre	
		Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain		Pounds of Straw	Bushels of Grain
1	Appler (seed North Carolina grown)	55.5	60.5	47.8	52.2	32	1110	37.8
2	Re-improved Appler	46.5	58.5	44.3	55.7	32	930	36.6
3	Appler (seed Georgia grown)	55.0	57.0	49.2	50.8	33	1100	34.5
4	Argentine (B. P. I. No. 206)	45.0	55.0	45.0	55.0	33	900	33.3
5	Bancroft	53.0	53.0	50.0	50.0	32	1060	33.1
6	Appler	41.0	52.0	44.1	55.9	32	820	32.5
7	Culberson (seed North Carolina grown)	53.0	52.0	50.5	49.5	33	1060	31.5
8	Red Rust Proof	52.0	50.0	51.0	49.0	32	1040	31.3
9	Danish Island	84.5	47.5	64.0	36.0	31	1690	30.6
10	B. P. I. No. 511	31.0	47.0	39.7	60.3	35	620	26.8
11	Virginia Turf	51.0	41.0	55.4	44.6	34	1020	24.1
12	Golden Giant Side	52.0	33.0	61.2	38.8	30	1040	22.0
13	White Tartar King	55.5	33.5	62.4	37.6	33	1110	20.3
14	Culberson (B. P. I. No. 273)	23.0	33.0	41.1	58.9	33	460	20.0
15	Burpee's Welcome	39.0	31.0	55.7	44.3	32	780	19.4

TABLE XIII—OAT VARIETY TEST—IREDELL FARM 1914.

Rank According to Yield Per Acre	Varieties	Yield Per Plat		Yielding Capacity		Weight, Measured Bushel of Grain	Yield Per Acre	
		Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain		Pounds of Straw	Bushels of Grain
1	Fulghum	74.5	50.5	59.6	40.4	29	1490	34.8
2	Appler	46.0	34.0	57.5	42.5	23	920	29.6
2	Burt	57.5	32.5	63.9	36.1	22	1150	29.5
3	Red Rust Proof	78.5	31.5	71.4	28.6	25	1570	25.2
4	Argentine (B. P. I. No. 206)	53.0	22.0	70.7	29.3	24	1060	18.3
5	Bancroft	55.0	20.0	73.3	26.7	24	1100	16.7
6	Virginia Turf	83.0	17.0	83.0	17.0	22	1660	15.4

VARIETIES OF WHEAT AT CENTRAL FARM.

The results of the wheat variety test in 1912 at the Central farm are recorded in Table 14. Seventeen varieties were tested. Three (1A, 2A, and 4A) of these being selections that had been improved in the breeding plats. The first was a selection from Leap's Prolific. The names of the original varieties of the other selections are unknown. The first selection takes first rank in yield, and Purple Straw and Red May take second rank. Of the fifteen varieties that were tested, ten were smooth and five were bearded. The smooth averaged 12 and the bearded 9 bushels per acre, this being three bushels in favor of the smooth-headed varieties. The weight of a measured bushel of each variety was assumed to be sixty pounds. All the plats on this farm are one-twentieth of an acre in size.

In 1913, on the Central Station farm, twenty-one varieties of small grains were tested, nineteen of wheat and two of rye. These results are embodied in Table 15. Australian Red, Red Wonder, and Purple Straw with equal yields take first rank. Australian Red in the test of the previous year (1912) was the lowest yielder in a test of sixteen varieties. Varieties frequently shift from one end of the column to the other in the change of a single season.

Some extraordinary claims had been made for the Eden wheat in respect to the small amount required to seed an acre. To test this claim, three seedings at the rates of one peck, two pecks, and three pecks per acre were made. The rate of seeding for all the other varieties was six pecks per acre. The Eden at the rate of three packs per acre takes rank in yield along with the highest of the other varieties. The other two seedings of Eden are low in yield, but two other varieties of normal seeding are still lower than the Eden. The growth of this variety in the field shows that it does tiller unusually well. The thin seeding of this variety, as would be the case with other varieties, however, has much to do with the tillering. The Eden wheat was not continued in the tests after this year, and this one test does not settle the claims made for it one way or the other. In all probability this variety is the same as the Stoner's Miracle wheat.

Of the 16 normal seedings, 8 were smooth and 8 were bearded. Both bearded and beardless averaged in yield 8.3 bushels per acre, there being no advantage in favor of one type over the other. All yields are comparatively low. This is doubtless explained by the fact that rust seriously affected the wheat crop of the whole State during the season of 1913. The average of the weight of a measured bushel is practically up to standard; however, Virginia and Miller's Choice each fell 4 pounds below standard weight per bushel. Purple Straw and Lancaster each weighed two pounds above standard. All the rest range from 58 to 60 pounds. During this year at this farm there were no comparative seedings from home-grown and imported seed. All varieties were seeded November 4.

TABLE XIV—WHEAT VARIETY TEST—CENTRAL FARM 1912.

Rank According to Yield Per Acre	Varieties	B=Bearded S=Smooth	Yield Per Plat		Yielding Capacity		Yield Per Acre	
			Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain	Pounds of Straw	Bushels of Grain
1	1 A (selection from Leap's Prolific)	S	101.00	95.00	51.5	48.5	1010	15.8
2	Purple Straw	S	102.00	81.00	55.7	44.3	1020	13.5
2	Red May	S	99.00	81.00	55.0	45.0	990	13.5
3	Harvest King	S	97.50	78.50	55.4	44.6	975	13.1
4	Golden Chaff	S	94.75	77.25	55.1	44.9	948	12.9
5	Leap's Prolific	S	69.00	75.00	47.9	52.1	690	12.5
6	Currell's Prolific	S	100.50	72.50	58.1	41.9	1005	12.1
7	Fultz-Mediterranean	S	75.00	63.00	54.4	45.6	750	10.5
8	Lancaster	B	45.00	31.00	59.2	40.8	900	10.3
9	Red Wonder	B	46.50	30.50	60.4	39.6	930	10.2
10	2 A (selection)		43.00	30.00	58.9	41.1	860	10.0
11	Fultz	S	92.50	58.50	61.3	38.7	925	9.8
12	4 A (selection)		36.50	28.50	56.2	43.8	730	9.5
13	Dietz-Mediterranean	B	40.50	27.50	59.6	40.4	810	9.2
14	Fulcaster	B	39.50	26.50	59.8	40.2	790	8.8
15	Klondyke	S	37.00	23.00	61.7	38.3	740	7.7
16	Australian Red	B	31.00	21.00	59.6	40.4	620	7.0

TABLE XV—WHEAT AND RYE VARIETY TEST—CENTRAL FARM 1913.

Rank According to Yield Per Acre	Varieties	B=Bearded S=Smooth	Yield Per Plat		Yielding Capactiy		Weight, Measured Bushel of Grain	Yield Per Acre	
			Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain		Pounds of Straw	Bushels of Grain
1	Australian Red	B	49.25	27.25	64.4	35.6	58	985	9.3
1	Red Wonder	B	45.50	27.50	62.3	37.7	59	910	9.3
1	Purple Straw	S	41.00	29.00	58.6	41.4	62	820	9.3
2	Leap's Prolific	S	43.50	27.50	61.3	38.7	60	870	9.1
3	Red May	S	42.50	26.50	61.6	38.4	59	850	8.9
4	Stoner-Miracle (B. P. I. No. 2980)	B	34.50	26.00	57.0	43.0	59	690	8.5
4	Eden Wheat (seeded 3 pecks to acre)	B	45.50	26.50	63.2	36.8	60	910	8.8
5	Dietz-Mediterranean	B	44.75	25.25	66.8	33.2	58	895	8.8
6	Martin's Amber (B. P. I. No. 1974)	S	50.50	25.50	66.4	33.6	60	1010	8.5
7	Fulcaster	B	45.00	25.00	64.3	35.7	59	900	8.5
8	Fultz-Mediterranean (B. P. I. No. 1957)	S	38.50	24.00	61.6	38.4	59	770	8.1
9	Miller's Choice	B	39.50	22.50	63.8	36.2	56	790	8.0
9	Fultz (B. P. I. No. 1923)	S	36.75	23.75	60.7	39.3	59	735	8.0
10	Poole (B. P. I. No. 1979)	S	41.00	23.50	63.6	36.4	59	820	7.9
10	Lancaster	B	46.50	24.50	65.5	34.5	62	930	7.9
11	Eden Wheat (seeded 2 pecks to acre)	B	46.25	22.75	67.0	33.0	60	925	7.6
12	Eden Wheat (seeded 1 peck per acre)	B	34.50	21.50	61.6	38.4	59	690	7.3
13	Fultz	S	34.50	20.50	62.7	37.3	60	690	6.8
14	Virginia (B. P. I. No. 3277)	B	36.50	18.00	67.0	33.0	56	730	6.4
1	Abruzzi Rye	B	110.50	34.00	76.5	23.5	56	1105	8.1
2	Common Rye	B	50.00	11.00	81.9	18.1	56	500	3.9

TABLE XVI—OAT VARIETY TEST—CENTRAL FARM 1912.

Rank According to Yield Per Acre	Varieties	Yield Per Plat		Yielding Capacity		Weight, Measured Bushel of Grain	Yield Per Acre	
		Pounds of Straw	Pounds of Grain	Per Cent Straw	Per Cent Grain		Pounds of Straw	Bushels of Grain
1	Burt	65.0	69.0	48.5	51.5	26.5	1300	52.1
2	Bancroft	71.0	71.0	50.0	50.0	29.0	1420	48.9
3	Red Rust Proof	77.0	70.0	52.5	47.5	31.0	1540	45.2
4	Appler	69.0	61.0	53.1	46.9	29.0	1380	42.1
5	Swedish Select	75.0	60.0	55.6	44.4	30.0	1500	40.0
6	Virginia Turf	78.0	67.0	53.8	46.2	34.0	1560	39.4
7	Black Spring	52.0	54.0	49.1	50.9	29.0	1040	37.2
8	Ohio Winter	76.5	50.5	60.2	39.8	30.0	1530	33.7
9	White Spring	62.0	49.0	55.9	44.1	29.5	1240	33.2
10	Black Gotham	52.0	39.0	57.2	42.8	25.5	1040	30.6
11	Sixty Day	41.5	40.5	50.6	49.4	28.0	830	28.9
12	Number 6143	57.0	33.0	73.3	36.7	24.0	1140	27.5
13	Lincoln	55.0	38.0	59.2	40.8	28.0	1100	27.1
14	Irish Victor	42.0	35.0	54.6	45.4	26.0	840	26.9
15	Big Four	42.0	39.0	51.9	48.1	29.0	840	26.9
16	Silver Mine	51.5	38.5	57.2	42.8	29.0	1030	26.5
17	Number 6203	53.0	40.0	57.0	43.0	32.0	1060	25.0
18	Green Mountain	52.5	32.5	61.8	38.2	28.5	1050	22.7
18	Golden Fleece	53.0	32.0	62.4	37.6	28.0	1060	22.8
19	Tzar of Russia	46.0	31.0	59.7	40.3	28.5	920	21.7
20	Improved American	52.0	25.0	67.5	32.5	24.0	1040	20.8

RESULTS WITH ABRUZZI RYE.

Abruzzi rye outyielded the common rye by 4.1 bushels per acre, and according to the records the former is 10 days earlier than the common rye. The yield of straw of the Abruzzi was more than double that of the common rye. In the test of 1914, the Abruzzi rye yielded 42 pounds per plat while the common rye only yielded 27 pounds on the same size plat. This is a difference in yield of 15 pounds per plat or 5.3 bushels per acre in favor of the former variety. The Abruzzi in this test was two weeks earlier than the common rye. The rye varieties were seeded on one-tenth acre plats during the previous fall.

VARIETIES OF OATS AT THE CENTRAL FARM.

In 1912 there was an oat variety test conducted on the Central farm, the results being recorded in Table 16. The yields are good with a majority of the varieties. Burt, a spring variety fall sown, takes first rank with a yield of 52 bushels per acre. Bancroft, Red Rust Proof, and Appler, three winter varieties, take second, third and fourth places, respectively, in rank of yield of grain. All except one are below standard in weight of a measured bushel. Some of them are too far below, for instance, Improved American weighs only 24 pounds to the bushel, this being 8 pounds below the weight of a standard bushel. This is the lowest recorded, but some of the others are far too low in this respect. The varieties were seeded on October 25.

AVERAGE RESULTS OF VARIETY WHEAT TESTS AT DIFFERENT FARMS.

The first variety wheat test at the Iredell farm was conducted in 1901. It was not repeated until 1904, but since the latter date has been repeated continuously since with the exception of 1909. The data of these tests with that from those subsequently conducted have been utilized in compiling Table 17. A nine-years' comparison has been made for two varieties; and a seven-years' comparison for five varieties. The varieties in the first comparison have been repeated in the second whenever the years of the tests of the different varieties were the same. The tests have not been continuous, but the years in which each test has been conducted have been the same for each comparison.

The data secured in the tests carried on at the Central farm since 1903 have been utilized in compiling Table 18. Two varieties in this table have been compared for ten years; and six, including the first two, have been compared for nine years. The same explanation of Table 17 applies to Table 18.

In each table only the names of the varieties, the number of years tested, and the average yield in pounds of straw and bushels of grain, have been used. These tables have been submitted without detailed discussion mainly for reference. They are valuable for showing the records for yields of the varieties for a long series of tests.

TABLE XVII—AVERAGE YIELDS OF WHEAT FOR A SERIES OF YEARS—IREDELL FARM.

Varieties	B=Bearded S=Smooth	Number Years Tested	Yield Per Acre	
			Pounds of Straw	Bushels of Grain
Fulcaster	B	9	1377	15.5
Dietz-Mediterranean	B	9	1354	13.8
Fulcaster	B	7	1603	18.0
Leap's Prolific	S	7	1446	17.9
Purple Straw	S	7	1546	17.0
Red Wonder	B	7	1817	16.9
Fultz	S	7	1315	16.1

TABLE XVIII—AVERAGE YIELDS OF WHEAT FOR A SERIES OF YEARS—CENTRAL FARM.

Varieties	B=Bearded S=Smooth	Number Years Tested	Yield Per Acre	
			Pounds of Straw	Bushels of Grain
Purple Straw	S	10	911	13.5
Dietz-Mediterranean	B	10	876	10.8
Red May	S	9	967	14.0
Purple Straw	S	9	921	13.7
Red Wonder	B	9	889	11.8
Lancaster	B	9	894	11.1
Dietz-Mediterranean	B	9	901	11.0
Fulcaster	B	9	1028	10.9

Comments and Conclusions.

It is of the highest importance that tests of this character be repeated for a number of years before definite conclusions are attempted to be drawn. Only in the average results of a series of tests is there any hope of eliminating the inequalities of the soil and the non-uniformity of the seasons under which all field crops have to be grown. The mechanical side of experimental work should be free from the possibility of error. Methods and means of planting, cultivating, and harvesting, and devices for weighing and measuring should be as near perfect as mechanical ingenuity can make them. Such is not always available in ordinary farm equipment. This is a possible added error to be eliminated in the average results from a series of experiments. The results from experiments that have been conducted for only one or two years should be simply considered as indications rather than as definite conclusions.

The old idea that during a good season smooth varieties will outyield bearded ones, and that during an unfavorable season for wheat, bearded

varieties will outyield smooth varieties, and that for a series of years, eight or ten bearded varieties will outyield smooth ones on an average, is not sustained by the results of these experiments. In the discussion of the tables, eleven comparisons between yields from smooth and from bearded varieties have been made. The smooth excelled in eight of these, the bearded in only three. In most of the instances the difference either way is only a very small fraction of a bushel. On the Buncombe farm in 1914 the yields from four smooth varieties sown from home-grown seed averaged 2.5 bushels more than the yields from four bearded varieties sown from home-grown seed. In 1912, in the experiments at the Central Station farm, the average yields of ten smooth varieties were compared with the average yields of five bearded varieties. The difference was 3 bushels in favor of the smooth varieties. These two are the largest single differences and they both are in favor of the smooth wheats. In 1913, a poor wheat year, the smooth varieties averaged a greater yield by a small fraction of a bushel on both the Buncombe and the Iredell farms, and the two averaged the same on the Central farm. In the compiled table for the Buncombe farm, four varieties, two smooth and two bearded, were tested for four consecutive years. The average yield of the smooth varieties excelled the bearded by 0.4 bushel. In the compiled table for the Iredell farm, seven varieties, three smooth and four bearded, were tested for five consecutive years. The average yield of the bearded varieties in this case excelled the smooth by 0.3 bushel. In Table 18 are the compiled results on the Central farm for several years. Purple Straw, a smooth variety, excels Dietz-Mediterranean, a bearded variety, in a ten-years' average by 2.7 bushels. Six varieties, two smooth and four bearded, were tested for nine years. The average yield of the smooth varieties is 2.6 bushels more than that of the bearded varieties. Practically all the evidence of these experiments is in favor of the smooth varieties out-yielding the bearded.

Five comparisons have been made between yields from home-grown seed and from imported seed. Three are in favor of the home-grown seed. In 1914 sixteen varieties, eight from home-grown seed and eight from imported seed, were tested on the Buncombe farm. The yields from the home-grown seed averaged 5.8 bushels more than from the imported seed. This is the most pronounced result in favor of the home-grown seed. The differences in all the other comparisons are mere fractions of a bushel. This is a bit more evidence confirming the fact that home-grown, acclimatized seed wheat outyields imported, unacclimatized seed.

"Imported seed" here means that the seed were not grown on the farm or in the immediate vicinity of the farm, but were secured in some other part of the State or from an adjoining State. Had it been brought in from the far West or some other part of the country with very dissimilar conditions, the results doubtless would have been more pronounced in favor of the home-grown seed.

Abruzzi rye has been found to far excel the common rye in yield of both grain and straw. It is also ten days to two weeks earlier. It is especially recommended for those who wish to sow rye for late fall or early spring pasture, or for winter cover crop.

There has been found, upon the whole, about fifty per cent difference between October sown and December sown wheat on the Iredell Test Farm. In every instance there is a progressive decrease in yield from the sowing on October 10 to that on December 21. This is based on two years tests and the results will doubtless not be changed by future experiments. Wheat in the vicinity of the Iredell Test Farm should be sown as early in October as danger from the Hessian fly will permit. However, between the usually small depredations of the Hessian fly by early sowing and a reduction in yield of more than one-half by late sowing, there should be little hesitancy in choosing the depredations of the Hessian fly.

SEPTEMBER, 1915 BULLETIN 233

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE

AND THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

RALEIGH AND WEST RALEIGH

Common Diseases of Poultry

A Corner in the Laboratory of Poultry Investigations and Pathology, Animal Industry Division, North Carolina Experiment Station, West Raleigh.

Bulletins of the Station Will be Sent Free to Citizens of the State on Request

RALEIGH
EDWARDS & BROUGHTON PRINTING COMPANY
STATE PRINTERS
1915

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE

AND THE

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

BOARD OF AGRICULTURE

*W. A. GRAHAM, *Chairman*, Raleigh.

F. P. LATHAM.....Belhaven	*A. T. MCCALLUM.....Red Springs
C. W. MITCHELL.....Aulander	*C. C. WRIGHT.....Hunting Creek
*R. L. WOODARD.....Pamlico	WILLIAM BLEDSOE.....Gale
CLARENCE POE.....Raleigh	W. J. SHUFORD.....Hickory
*R. W. SCOTT.....Haw River	A. CANNON.....Horse Shoe

BOARD OF TRUSTEES OF THE COLLEGE

GOVERNOR LOCKE CRAIG, *Chairman.*

M. B. STICKEY.....Concord	*T. T. THORNE.....Rocky Mount
T. T. BALLINGER.....Tryon	*C. W. GOLD.....Greensboro
W. H. WILLIAMSON.....Raleigh	T. E. VANN.....Como
O. L. CLARK.....Clarkton	P. S. BOYD.....Mooresville
EVERETT THOMPSON Elizabeth City	W. E. DANIEL..... Weldon
R. H. RICKS.....Rocky Mount	*W. H. RAGAN.....High Point
O. MAX GARDNER.....Shelby	W. B. COOPER.....Wilmington
M. L. REED.....Biltmore	J. P. MCRAE.....Laurinburg

*D. H. HILL (President College), West Raleigh.

STATION STAFF

B. W. KILGORE.....Director	[1] J. M. JOHNSON.....Farm Management
C. B. WILLIAMS..Vice-Director, Agronomist	F. R. BAKER, Assistant Drainage Engineer
W. A. WITHERS.....Chemist	R. O. CROMWELL, Assistant, Plant Diseases
FRANKLIN SHERMAN, JR.....Entomologist	[2] A. J. REED.....Dairy Farming
W. N. HUTT.....Horticulturist	STANLEY COMBES, Assistant, Dairy Farming
G. A. ROBERTS.....Veterinarian	F. S. PEDEN.....Beef Cattle
[1] C. R. HUDSON.....Farm Demonstration	[2] J. B. MCVEAN.....Pig Clubs
J. P. PILLSBURY.....Horticulturist	[2] J. A. AREY.....Dairy Farming
H. R. FULTON.....Plant Diseases	[2] H. C. IKELER.....Beef Cattle
Z. P. METCALF.....Entomologist	[2] A. G. OLIVER.....Poultry Clubs
DAN T. GRAY.....Animal Husbandry	EARL HOSTETLER,
W. R. CAMP.....Marketing	Assistant, Beef Cattle and Swine
J. M. PICKEL.....Feed Chemist	[3] F. R. FARNHAM...Asst. in Dairy Farming
W. G. HAYWOOD.....Fertilizer Chemist	[3] A. L. JERDAN.....Assistant in Beef Cattle
L. L. BRINKLEY.....Soil Survey	W. C. NORTON..Assistant iin Bacteriology
R. G. HILL.....Assistant Horticulturist	[1] T. E. BROWNE, Asst. in Charge Boys' Clubs
[2] W. E. HEARN.....Soils	[1] A. K. ROBERTSON.....Asst. in Boys' Clubs
R. S. CURTIS, Associate in Animal Industry	[1] MRS. C. MCKIMMON,
J. K. PLUMMER.....Soil Chemist	Assistant in Charge Girls' Clubs
S. C. CLAPP.....Assistant Entomologist	[1] MISS MARGARET SCOTT,
W. H. EATON.....Dairy Experimenter	Assistant in Girls' Clubs
G. M. GARREN....Plant Breeding—Cereals	E. B. HART.....Assistant Chemist
[1] E. H. MATHEWSON.....Tobacco Expert	F. E. CARRUTH.....Assistant Chemist
J. Q. JACKSON.....Assistant Chemist	J. R. MULLEN.....Assistant Chemist
L. R. DETJEN....Assistant Horticulturist	F. B. SHERWOOD.....Assistant Chemist
A. R. RUSSELL,	B. SZYMONIAK,
Assistant in Field Experiments	Demonstrator in Fruit and Truck Crops
R. Y. WINTERS.....Plant Breeding	C. D. MATTHEWS..Assistant Horticulturist
B. F. KAUPP,	F. N. MCDOWELL.....Soil Survey
Poultry Investigator and Pathologist	R. W. LIEBY.....Assistant Entomologist
W. F. PATE.....Agronomist—Soils	D. T. MCCARTY.....Assistant Chemist
E. C. BLAIR..Assistant Agronomist—Soils	MISS MARY S. BIRDSONG, Sec'y to Director
E. S. DEWAR.....Assistant Chemist	A. F. BOWEN.....Bursar
[4] H. M. LYNDE.....Drainage Engineer	

R. W. COLLETT.....Assistant Director Branch Stations
F. T. MEACHAM.....Assistant Director Iredell Branch Station, Statesville
J. H. JEFFERIES.....Assistant Director Pender Branch Station, Willard
C. E. CLARK.....Assistant Director Edgecombe Branch Station, Rocky Mount
[1] E. G. MOSS.....Assistant Director Granville Branch Station, Oxford
S. O. PERKINS.....Assistant Director Buncombe and Transylvania Stations, Swannanoa

---

The members marked with * are members of the Joint Committee for Agricultural Work, and the Station is under their direction.

[1] In coöperation with the U. S. Department of Agriculture, Bureau of Plant Industry.
[2] In coöperation with the U. S. Department of Agriculture, Bureau of Soils.
[3] In coöperation with U. S. Department of Agriculture, Bureau of Animal Industry.
[4] In coöperation with the U. S. Department of Agriculture, Office of Experiment Stations.

DISEASES OF POULTRY

By B. F. Kaupp, Poultry Investigator and Pathologist.

FOREWORD.

The last available census of the United States gives the total valuation of eggs produced in North Carolina for that year as $4,256,769. This does not include eggs from poultry kept on the town lots and these would greatly swell the above amount.

More poultry and eggs should be produced in North Carolina. The climate of this State is well adapted for raising and keeping poultry and some of the largest markets in the world are easily accessible by either express or parcel post.

In this bulletin there will be discussed, first, external parasites, or those parasites infesting the skin of the fowl robbing the birds of blood and causing irritation by biting and crawling. These vermin are classed as one of the greatest enemies of poultry as they not only, at time, carry germs of disease, but also sap the birds of their vitality, cause weaklings, a loss of flesh, a lack of egg production, and make the birds liable to the attacks of a number of diseases.

Internal parasites will also be discussed, after which some of the more common contagious diseases will be taken up.

Every season of the year brings its variety of troubles to the flocks and one of the fundamental principles in attaining success in raising and keeping poultry, is a proper understanding of some of the more common diseases and how to guard against them by proper sanitation.

It is the intention to give a few hints along these lines and it is hoped that they will be helpful to the people of the State who keep poultry either for pleasure or profit.

Following the discussion on diseases is found a short description of the internal organs of the fowl, which includes the organs of respiration and digestion as well as the reproductive organs of the hen and cock. The proper way to open and examine the fowl after death is also discussed.

EXTERNAL PARASITES.

Fowls heavily infested with any of the external parasites are unprofitable and many kinds of external parasites when in enormous numbers, as is often the case, cause the death of the infested bird.

In order to treat birds and rid them and their premises of parasites it is essential to know something of their life, history and habits.

Among the more common external parasites affecting birds may be mentioned lice, chiggers, air sac-mite, fleas, chicken bugs, chicken ticks, and ring worm.

Description and Kinds of Lice.

Lice are biting insects. Their bodies are flat and the mouth parts are arranged for biting. They live upon the secretions of the body,

skin and feathers. The insect consists of three parts—head, thorax and body. The head is provided with jointed antennae or feelers. In most lice the antennae are provided with five joints. The eyes are located just back of the antennae. In some species the thorax is long and narrow; in others it is short and globular. The thorax is provided with three pairs of legs. Each free extremity of the legs is provided with two bristles, or with one or two claws, which enables them to hold onto their host. The body and legs are more or less covered with bristles.

Each kind of bird has its own peculiar kind of lice which live upon that particular kind of bird and no other. Two distinct varieties are commonly found on chickens. These are scientifically known as the Menopon biseriatum and the Menopon pallidum. The former is the larger of the two and is commonly known as the large chick or head louse, while the latter, smaller in size, is commonly found on the bodies of the adult birds. There is still another variety of louse which infests chickens, but the two mentioned are by far the most common.

On turkeys there may be found two kinds; the more common variety is scientifically known as the Gonoides stylifer.

Upon ducks and geese are found other distinct varieties or lice, while the pigeon is infested with still another, the Lipeurus baculus. This is the long slender louse with long and narrow head, thorax and abdomen so commonly seen in the pigeon cotes.

The female louse is a trifle larger than the male. Lice multiply or propagate by laying eggs which are oval in shape and white in color. These are fastened to the barbs of the feathers by the female with a small amount of cement with which she is provided. In a few days, usually ten days to two weeks, depending on the temperature and other conditions, the young louse escapes from the egg by raising a small cap or piece of the egg covering. The young are lighter in color than the adults but have about the same shape and appearance otherwise. The females are usually more numerous than the males. The lice now grow to full development and under favorable conditions may live for several months. During their growth to maturity they molt several times, each time taking on a slightly darker tinge.

Lice multiply very rapidly in hot weather, at which time they find conditions for existence most favorable. One pair of lice, under the most favorable conditions, may possibly be grandparents to over 100,000 descendants in the short space of two months.

Symptoms of Lousiness—

Lice produce irritation and when in large numbers, they seriously interfere with the health, growth, and development of the birds as well as cut down egg production and fattening processes.

A lousy bird may scratch and pick at its feathers. It shows signs of being drowsy, may refuse to eat; growing birds do not make proper body growth.

Young chicks infested by large numbers of lice sit around, mope with wings hanging down and in a few days, usually ten days or two weeks (depending upon the abundance of lice) may die. For this reason it is the common experience that brooder chicks thrive better, and grow faster, than chicks hatched by the hen.

Lousy sitting hens may desert their nests and their combs turn dark in color. Finally the birds, unable to rest day or night as a result of the irritation caused by the crawling, biting insects, become emaciated and die.

It is not difficult to find the lice on a lousy hen. Part the feathers and the lice will be observed running in different directions and close to the skin.

The lice are thickest in the fluff near the vent and under the wings.

Treatment—

If the large head lice are found upon the heads of the young chicks it is good treatment to grease the tops of the heads with plain vaseline or lard. Care should be exercised not to apply too much. Just a small amount is sufficient to close the breathing pores of the lice and kill them by asphyxiation. The older birds are best treated by either dipping in a good coal tar dip as a one per cent kreso dip or by dusting with an insecticide.

A very effective insect powder is made by taking crude carbolic acid, one pint, and gasoline, three pints, mixing with sufficient plaster of paris to make a slightly moist mixture. (Two and a half pounds is usually sufficient), then rub the mixture through a sieve made of a piece of common fly screening. It is better to screen the mixture onto a piece of paper spread out on the table. Allow the screen mixture to lie where it was sieved for about two hours, when the powder will be found to be dry. It is now ready for use. If it is not used at once it must be kept in a container with a tight-fitting lid, such as a baking powder can. Take an old talcum can or a small baking powder can and punch the top full of holes, and sift as in using a pepper box.

In applying the mixture to the birds, grasp the bird with the left hand, hold with head down, dust a small quantity of the powder into the feathers and rub the feathers the wrong way, thus working the powder down to the skin. Dust all parts of the body. A bird thoroughly dusted need not be redusted for three months unless the premises are badly infested. The hen house should be thoroughly cleaned and sprayed with a strong coal tar disinfectant. Four tablespoonfuls of creolin to each gallon of water may be used.

Dust all hens at time of sitting and again the day they are taken from the nests.

The Mite (Chigger.)

Description—

This parasite is minute in size and hence commonly known as the chicken mite. It varies in size up to half the size of a common pin head. The body is oval in shape and varies from a light yellow tinge in the young state to a bluish red color in the adult state. The head parts consist of a conical shape piercing apparatus with which it pierces the skin and sucks serum or blood. The free extremity of the last segment of the legs are provided with hooklets or claws which enables it to hold onto its host.

The mite lays its eggs in cracks of the roost, walls, nests, or filth of the hen house. If the weather is warm the eggs hatch in a few days.

The young mites are much smaller than the adult, but will in the course of a very few days reach the sexually mature stage.

In hot weather, as in July and August, mites multiply very rapidly and thousands have been seen upon a single hen.

Thousands of mites crawling, biting and sucking blood causes loss of blood and emaciation. The bird cannot rest, day or night, and finally succumbs to the ravages of the parasites. Sitting hens leave their nests, laying hens cease to lay. Such birds may be found dead under the roosts in the morning.

Treatment—

Pour kerosene or gasoline on the roosts. Gasoline is a mild disinfectant and a powerful destroyer of parasites.

Dust the hens with the insect powder described before. Clean the hen house. Thoroughly scrub and spray every square inch to saturation, reaching all cracks with a two-per-cent solution of creolin, kreso dip, zenoleum or some other equally good coal tar preparation. Dust sulphur into the nests.

Fumigation with sulphur fumes or formaldehyde gas is not practical as the buildings, as a rule, are too open and the fumes cannot be confined in sufficient quantities long enough to be effective.

If the weather is hot the hen may be dipped in a two per cent solution of some good coal tar product.

Scaly Legs.

There is a common condition in some localities called scaly legs, so called because the legs have accumulated upon them scales or scabs.

This is one form of scabies that is caused by a parasite belonging to the same family as the one commonly causing scabies or mange in the horse and dog. It is minute in size, being scarcely larger than the point of a pin.

Symptoms—

The parasite infests the shanks or unfeathered portion of the legs only, that is, from the hocks down to and including the upper and lateral sides of the toes. The parasite is oval in shape with mouth parts arranged for cutting the skin. It lives on the serum which exudes from the injured part. The parasites burrow between and gradually work their way under the edges of the scales where, by their irritation, a small amount of serum exudes which dries and which particle contributes to the formation of large scabs. The scaly leg parasites multiply by laying eggs in galleries in the skin and when they hatch out in about ten days they are practically invisible to the eye. These scab parasites develop very rapidly in warm weather. By increasing numbers and continuous biting, the scales of the legs become forced up out of a normal level by the accumulation of dried serum. Finally the legs appear with more or less large masses of hard crusts or scales. When these scales are removed it is seen that the under surface is moist. In this moisture may be oberved minute light colored specks, almost pin-point in size. When removed by aid of the point of a needle or pin and placed under a low power magnifying lens they may be seen to move.

Mode of Spread—

While these scab parasites go through their entire life cycle on the legs of the host, they will live for several days off the bird.

Birds become infested by coming in contact with other birds with scaly legs or by being placed in shipping coops or placed in buildings or runs in which birds with scaly legs have beep kept.

No birds should be sold for breeding purposes from a flock with scaly legs nor should such birds be exhibited in the show room or shipped in crates in which breeding stock are to be shipped.

Treatment—

In treating a bird with scaly legs first soak the scabs with warm water. With a nail brush remove all scabs possible, after which scrape with a dull knife. After the legs are dry saturate with gasoline as the oil penetrates deeper than watery solutions and is a powerful destroyer of parasites. Repeat this treatment once every five days. A hot solution of lime and sulphur dip as used in sheep dipping has been used with excellent results.

It is extremely difficult to thoroughly clean an infested farm, as a great number of parasites will be found in the nests, roosts and other places.

INTERNAL PARASITES.

Birds, at times, are infested by many different varieties of worms. Among these common worms may be mentioned several groups as the tape worms and round worms of the intestinal tract, and the round worm of the trachea or wind pipe—the gape worm. In addition to these, there are found less frequently the flukes and the thorn headed worms.

The most common internal parasites are the round worms. The round worms are cylindrical in shape, tapering slightly towards the head and some varieties markedly at the posterior third. They are white to pinkish white in color. The sexes are distinctly different, the female being larger.

Intestinal round worms multiply by producing eggs which pass out to the ground with the droppings. Water and food become soiled with the droppings laden with the eggs and thus other birds consuming contaminated food become infested.

It is advisable in killing birds for food purposes to examine the intestinal content for worms. The intestine can be easily opened by aid of a sharp slender pointed knife.

THE LARGE ROUND WORM.

The large round worm is called the Ascaris Inflexa. It is present in over twenty-five per cent of the birds purchased on the market. It is round in shape and whitish-yellow in color and varies from one to two inches in length.

This worm is found in the small intestines. The body is rather rigid but when the live worm is taken from the intestine and placed in cold water, vigorous contractile movements are seen.

Symptoms—

Large numbers of intestinal worms cause a partial loss of appetite, unthrifty condition, unkempt appearance of the plumage, dullness and sluggishness with droopy wings and emaciation. The comb and face become pale or bluish, and in a few weeks the bird may die.

By observing the droppings closely an index to the digestive condition can be found. In intestinal parasitism an occasional worm will be passed.

Treatment—

In way of treatment it is found necessary to keep the yard and hen house clean. Water should be kept in drinking fountains and no depressions allowed about the yard for the accumulation of small pools of water. The feed should be given from clean troughs which should be disinfected daily by scrubbing with a five per cent solution of carbolic acid or other equally good disinfectant. All troughs should be so constructed that the birds cannot step in them.

When it is known that worms are present, the birds should be made to fast for twenty-four hours, then give each bird a teaspoonful of olive oil, and one teaspoonful of turpentine, separately.

If it is desired to treat the birds by giving the medicine in the feed, the following plan may be tried. Withhold feed for twenty-four hours, then mix ten grains of areca nut with shorts and water, for each bird, making the mixture about the consistency of batter. Pour the mixture in a long trough so that all the birds can get to the feed at the same time.

The Small Round Worm.

There is a small round worm, whitish in color and from one-fourth to one-half inch in length, which sometimes infests the caecum or blind pouches of the intestines. In many localities of the United States this worm is found in fifty per cent of the birds.

If the bird is infested by large numbers of worms similar conditions arise as are caused by the large round worm. Best results will probably be attained by giving powdered areca nut in five grain doses.

The Gizzard Worm.

Another worm is commonly known as the gizzard worm and has been known to cause great losses among chickens. It is a round worm with rather blunt extremities and measures about three-quarters of an inch in length. It inhabits the walls of the gizzard.

Symptoms—

This worm causes the birds to grow lazy and languid. The comb, face and wattles become pale. The fowl becomes emaciated and finally dies although the appetite is ravenous. The worms are found coiled in small nodules in the walls of the gizzard and are readily seen in making an examination after death of the bird.

Treatment—

Treatment similar to that recommended for other forms of intestinal round worm invasion is recommended. On account of the fact that the

worms are embedded in the lining of the gizzard, it is rather difficult for drugs to reach them, so medical treatment is usually not satisfactory. It is better to slaughter all birds of an infested flock, thoroughly disinfect as for chicken cholera, and move the location of the poultry house and run, if it is possible to do so, and start with a new flock. These fowls should not be sold as breeding birds as this will tend to spread the contagion. No birds should be kept on a premise until at least one year has elapsed from the time of disinfection. Unless cleaning and disinfecting are carried out in the minutest detail it will be of no avail as a piece of dropping the size of a pea may contain embryos and serve to again introduce the contagion into the flock.

The Gape Worm.

There is a worm which, when it gains a foothold in the flock, may prove a scourge to chick raising. This worm is commonly known as the gape worm.

The female reaches an inch or a trifle more in length and is round in shape. The head parts are provided with mouth parts by which means it holds tenaciously to the mucous membrane lining, the trachea or windpipe of the young chick. The male is less than a half to a third as thick as the female and scarcely more than a fourth of an inch in length. The male is always attached to the female so that the worms appear as one forked individual. Both hold onto the lining membrane of the trachea and by means of membranous teeth, wound the mucous membrane and suck blood from their host.

Reproduction is brought about by the female worm developing eggs which are oval in shape and which do not pass from the body of the female in which they develop till the worm is expelled from the trachea and the body degenerates. These eggs are then taken up by earthworms. These infested earth worms in turn may be eaten by the young chick and thus the chick becomes infested with the microscopic embryo or minute worms. As soon as the embryos or minute worms enter the digestive tract of the chick they penetrate the wall and locate themselves by selection by preference, in the trachea. If there are many of these minute worms they form a cluster and as the worms grow they gradually obstruct the air passage. Finally the chick, finding it difficult to get sufficient air into the lungs, gasps for air, throws its head high into the air, extends its head upwards and back over the dorsal part of the body, falls backwards, and dies from asphyxiation. The condition produced is called gapes because the chick gasps of "gaps" for air.

Chickens, turkeys, ducks, geese, pheasants, partridges, pea fowls, magpies, black storks, starlings, crows, parrots, swifts, woodpeckers, and martins are all subject to the disease.

Treatment—

Gently grasp the bird in the left hand and force its mouth open, using the thumb and forefinger, and insert into the trachea a doubled horse hair, forcing the loop past the worms, then twist and withdraw. Or a feather may be taken and stripped of all barbs except a few on the tip, then dipped into turpentine, passed down the trachea till the tip is past the mass, twist and withdraw and this will usually dislodge the worms.

As a precautionary measure it is well to feed only from containers constructed for the purpose and which can be kept clean. If the farm is known to be infested, the chicks should not be permitted to run on wet ground where they are likely to find earth worms; they should be kept on a board or concrete floor.

The Tape Worm.

There is a group of worms that are flat and ribbon shaped. They are commonly called tape worms. There are several varieties which infest the intestinal tract of most animals including man, horse, cow, dog, cat, rat, fish and poultry.

Description—

The tape worm is provided with a head, a neck and a body. The head is provided with an apparatus which serves as a means of holding on. This apparatus consists of four sucker discs and a number of hooklets. These hooklets are very small in size; they are, in fact, seen only by aid of the microscope. By means of this fixation apparatus the worm holds onto the mucous membrane lining the intestines and floats back in its content. The entire head is not as large as the head of a pin. The neck in most species infesting the intestinal tract of birds, is small, short and thick. The body varies in length according to the species of worm. The body is flat or ribbon shaped and consists of a chain of segments. In some species the segments close to the head are very narrow and short. As the distance from the head increases the segments become wider and longer. There are no distinct males and females as in round worms. The first segments close to the neck are not provided with generative or reproductive organs, but further down, or as the segments grow, they develop the generative organs. Each segment is now provided with both male and female generative organs and each segment fertilizes itself. After fertilization each segment develops many hundreds of eggs. After all these eggs are mature or fully developed the segment is spoken of as being ripe. The ripe segments detach themselves, sometimes one and at other times two, three or even four. These segments laden with mature eggs by the thousand, pass out to the ground with the droppings, where other birds, partaking of food or water contaminated or soiled by the infective droppings, may also become infested.

The tape worm has no digestive tract as is the case with the round worms. It lives by each segment absorbing its own food. This food consists of nutrients taken into the digestive tract of the host and digested. Hence when large numbers of these worms are present they absorb much valuable digested nutrients thus robbing the host. Infested birds become thin in flesh, in fact, emaciated. There may be a loss of appetite, an unthrifty appearance and the feathers present an unkempt appearance; sometimes death finally results.

Treatment—

If individual treatment is desirable, fast the birds twenty-four hours and give a teaspoonful of turpentine and a tablespoonful of epsom salts. Dissolve the salts in hot water.

If it is desired to avoid medicating each bird separately and to take chances on collective treatment, give three grains of powdered areca nut to each bird in a mash made of wheat shorts mixed with water, as suggested under round worms.

CONTAGIOUS DISEASES.

There is a group of contagious diseases which are accompanied by diarrhea. Among these diseases we find Black head, Chicken cholera, and White diarrhea.

Black Head.

Black head is scientifically known as Enterohepatitis because it affects the intestines and liver, and is called black head because the head is supposed to turn blue or bluish black. This is not always the case.

The disease affects turkeys and more rarely chickens. Among turkeys it causes great losses and in some parts of the country, poultrymen find turkey raising very difficult. Young turkeys are more frequently affected than the older ones, though the adult birds are frequently afflicted.

The disease is due to a single celled animal organism or parasite. It is necessary to magnify the germ several hundred times by aid of a microscope in order to see it.

The germs are found in the diseased areas of the liver and bowel and thousands are given off constantly in the droppings. The droppings, of course, pollute the water and the food and other birds become infected by consuming this polluted food.

Symptoms—

The symptoms are not noticeable till the disease has progressed for some time. The bird will first become dull, later the wings and tail appear droopy, and the bird sits around. Later the feathers appear ruffled and present an unkempt appearance. The bird shows a loss of appetite and grows gradually weaker, becomes emaciated, and in from three to ten days after showing the first symptoms, may die. The disease may assume a more chronic form and extend over a period of many months. Diarrhea appears, the discharge being of a yellowish green color.

Treatment—

It is necessary to do everything possible in the way of preventative measures to stop the spread of this disease from the premises. It is possible that the disease, in some cases, is perpetuated and spread by a hen or even a turkey possessing great resistance and having a chronic ulcer of the bowel. There is always some danger of introducing the disease into a flock or locality, by bringing birds into it from an infected flock. When outside birds are brought into a flock the purchaser should make sure that they come from a flock free of the disease.

As far as possible, disinfection should be carried out. As the turkeys usually roost in trees, upon fences, and upon the tops of buildings, it is very difficult to disinfect the premises.

Feed should be given from troughs and if chickens eat with the turkeys the top of the feed hopper or troughs should be slatted so the birds

cannot get their feet into them. Water or milk should be given from a container which is likewise protected.

Treatment—

Intestinal antiseptics are indicated. Permanganate of potash may be used in the water. A good way to handle this disinfectant is to use a pint jar, place some crystals of potassium permanganate in it and fill it with water. Have enough crystals till some remain in the bottom of the jar undissolved. Every time the troughs are refilled pour enough of this stock solution into the water to give it a slight purple tinge.

Sulphocarbolate of calcium, sulphocarbolate of sodium and sulphocarbolate of zinc, equal parts, have given good results. Of this mixture each bird should receive one-half grain three times a day. It may be dissolved and added to milk, or it may be dissolved in warm water and this water used to mix with a mash. If given in a mash it must be fed from long troughs so that all birds can get to it and each get approximately their proportion.

Fowl Cholera.

Fowl cholera is often called chicken cholera. It attacks chickens, turkeys, ducks and other birds. The discharge from the bowel of an infected bird contains millions of the germs causing the disease. Food or water becoming contaminated with the droppings of sick birds are a source of danger and causes a rapid spread of the disease.

Symptoms—

Birds with the disease are usually very thirsty and stand around the water troughs much of the time. After the bird takes the germs into its digestive tract the disease will appear in from three to seven days, depending on the resistance of the individual bird and the number of germs introduced. The onset of the disease may be so sudden that among a flock of birds which showed no symptoms of the disease the night before, one or two may be found dead under the roosts in the morning. If the disease is not abrupt and severe the bird will first be seen to have a loss of appetite, but will be very thirsty, due to a high fever. The fowl soon becomes very weak, often reeling as it walks. The feathers present an unkempt appearance, the bird mopes around, sits off by itself, is listless, trembles, becomes rapidly emaciated, the comb becomes dark and there is severe diarrhea.

Post Mortem Appearance—

Upon opening the abdominal cavity of a bird that has died of fowl cholera, the liver is noted to be very dark in color, tears easily and is two or three times its normal size. The intestines are congested and contain a frothy material. There may be hemorrhage in the lining or mucous membrane of the bowel and the contents may contain more or less blood. The spleen is large, dark and soft. (*The spleen is located in an angle formed by the posterior edge of the liver, the right side of the gizzard and the left side of the duodenal loop. It is shaped like a horse chestnut, dark reddish in color and about three-quarters of an inch in diameter at its longest axis.*) The kidneys are dark, appear more or less swollen and are soft. (The kidneys are the two irregular-shaped

bodies dark in color, normally, about one and one-half inches long and lie in an irregular cavity of the back bone.)

Treatment—

Care should be taken to not spread the disease to other premises, remembering that the germs of disease may be carried from an infected yard on the feet of man and animals.

The germs may be carried in a stream of water if it becomes polluted by yard drainage or by throwing birds dead of cholera into it. Buzzards feasting on the dead bodies of birds that have died of cholera may distribute infection to new premises miles away. The dead birds should by all means be burned. However, if this is not desirable, they should be covered with lime.

All feed should be given in troughs. The troughs should be slatted across the top so the birds cannot get their feet into them and contaminate the feed. Water should be kept in a similar container.

The hen house must be thoroughly cleaned and disinfected with a five per cent carbolic acid or some other equally good disinfectant. This work must be thoroughly done or it will be entirely without results. It is very difficult to disinfect the yards. If the yards can be plowed and a crop grown upon it the sun's rays will do much to disinfect it. The germs are very resistant and live for a long time outside the body.

Intestinal antiseptics are indicated. Use permanganate of potash as recommended under black head. Also the three sulphucarbolates are valuable. Six grains of bichloride of mercury and three grains of citric acid to the gallon of water, makes a solution one to ten thousand which is borne very well by poultry. The citric acid aids in dissolving the bichloride of mercury. Bichloride of mercury is slowly soluble in water and it is necessary to make sure that it is all dissolved.

White Diarrhea.

White diarrhea of baby chicks is a menace to the poultry raiser.

There are two forms of this disease. One form is due to a rod shaped germ microscopic in size and scientifically called the bacterium pullorum.

It has been determined that the ovaries of a hen that is producing eggs may be affected by this germ and that the eggs she produces may be infected. Because of this the chick may either die in the shell or in two or three days after it hatches. The baby chick may live longer or finally recover. Susceptible birds, that is, those capable of developing the disease may become infected by eating food contaminated with droppings of a bird infected by the disease.

The sick chicks are seen to have droopy wings, ruffled feathers and sleepy appearance. They huddle together and have little or no appetite, but cry much of the time. There is a discharge from the bowel which is brownish white or white and which adheres more or less to the vent fluff and the anus becomes "pasted up."

It appears that chicks which are hatched in the late fall, winter or early spring are freer from the disease than those hatched during the summer months. It seems that hot weather furnishes a more favorable condition for the development of the disease.

Sulphocarbolates, as recommended for black head, has given satisfactory results.

Baby chicks should be given sour milk from the start as we have found this one of the most effective and cheapest means of controlling the disease.

Chickenpox.

Chickenpox or sore head, as it is often called, is a contagious disease affecting the comb and face. Birds become infected in a similar manner as in other contagious diseases.

Fall, winter and spring bring about climatic conditions favorable to the development of the disease, hence it is more prevalent at these seasons of the year. There appears to be some relation between this disease and roup as both may occur in the same flock.

The first symptoms noted will be a small nodule on the comb or face which appears first as a pimple. This gradually becomes larger. Later the top sloughs off and the part becomes sore or ulcerated.

Treatment—

If the nodule is very small it may be treated by taking a tooth-pick, dipping it in pure carbolic acid, and lightly touching the top of the nodule, using care less the strong acid runs down into the surrounding parts. After twenty-four hours apply a small quantity of carbolized vaseline. The sores may be touched with iodine or with kerosene.

Sick birds should also be given a tablespoonful of castor oil.

Roup (Avian Diphtheria).

Roup is a very highly contagious disease. It may be differentiated from common cold by the characteristic offensive odor.

Cold, damp weather and drafts favor the development of roup.

Beware of a pale faced bird which frequently sneezes. Many of these birds have chronic forms of roup and when examined closely are found to give off an offensive odor. These birds perpetuate the disease and as soon as conditions arise which will render the balance of the flock more susceptible, the disease may affect many more birds of the flock.

Symptoms—

The disease manifests itself in three different forms or types. The nasal type, the eye type, and the mouth type.

In the nasal type the germs invade the mucous membranes of the upper air passages, that is, the nostrils and sinuses (cavities) of the head. These membranes become swollen and are stimulated to giving off much mucous, as a person with a "cold in the head." The anterior opening of the nasal passage is small as compared to the cavities of the head leading to it. As a result of the drying of small particles of the mucous discharge the opening becomes sealed and the bird is compelled to open its mouth to breathe. In addition to this it is often found that there has accumulated a mass of mucus in the cavities of the head located in front and below the eye, and that the walls of the sinus are forced out, forming a swelling in that region.

The membrane of the eye may likewise become affected as in the nasal form where a similar catarrhal condition may be noted. At night when

the eye is closed, the lids become adherent or stuck by the drying of the discharge which works its way between the lids.

It may also be found that the germs of the disease have invaded areas of the mouth. These areas appear as yellowish or yellowish-white patches on the mucous membrane.

Treatment—

If a bird is not a valuable one it is better to destroy it. It is well to remember that the head as well as the body must be buried deeply, or better, burned.

Thorough cleanliness and disinfection of the buildings is essential.

The germs of the disease can be carried on the hands, clothing, feeding utensils or on the feet of animals.

Always quickly isolate the sick birds.

If it is desired to treat the sick bird and to obtain the best results it will be necessary to at first procure a syringe with strong blub so as to force the liquid through the nasal canal. An ordinary medicine dropper bulb does not give force enough. Syringe out the parts with a twenty per cent solution of common baking soda. After a few minutes this will be found to have dissolved the mucous. Next syringe out the parts with equal parts of peroxide of hydrogen and water. This will thoroughly cleanse the parts and prepare them for the drug calculated to destroy the germs and allay the inflammation. Inject a quantity of the following:

Oil Thyme	30 minims.
Oil Eucalyptus	20 minims.
Menthol	10 grains.
Oil petrol	2 ounces.

Mix thoroughly.

All liquids injected into an inflamed mucous membrane should be warm. The material can be warmed by setting the bottle containing the mixture in hot water.

Treat the eye in the same manner as the nasal type and touch the ulcers in the mouth with a stick of nitrate of silver (lunar caustic).

THE VISCERAL ORGANS OF THE FOWL.

To perform an autopsy upon a bird that has died, lay the carcass on its back with the head directed away from the operator. Remove the

Fig. 1—*Visceral Organs of the Hen:* 1—the tongue and larynx, 2—the first portion of the œsophagus, 3—the crop, 4—the proventriculus or true stomach, 5—the gizzard, 6—the duodenal loop between which is located the pancreas, 7—the cæca or blind pouches which are given off at the juncture of the small intestines and the rectum or large intestines, 8—the rectum or large intestines, 9—the cloaca and anus, 10—the trachea, 11—the lungs, 12—the liver, 13—the gall bladder, 14—the spleen.

feathers from the breast and with a sharp knife open the abdominal wall, beginning on either side of the posterior portion of the breast bone and carry the knife forward beyond the "wish bone." Cut away the posterior abdominal wall and grasp the breast bone at its posterior portion, forcing it upward and forward, breaking it and then remove.

When the abdominal cavity is opened, the gizzard, which lays on the left side against the liver, abdominal wall, and posterior to the liver, proventriculus and spleen, will first be noted.

The duodenal fold or first portion of the small intestines is located to the right of the gizzard occupying a portion of the right half of the lower abdomen, and extends backward along the abdominal wall and terminates by a loop close to the cloaca and posterior abdominal wall.

The liver is noted to be a rather large dark gland which lays in the center of the anterior portion of the abdominal cavity with the apex of the heart in front and between the anterior portion of the fissure formed by the right and left lobes.

The spleen lays on the left side just superior to the left lobe of the liver.

The lungs occupy the chest or thoracic cavity.

The oviduct occupies a portion of the left side and is tortuous in the active state and measures from 18 to 20 inches in length. The ovary, when active, occupies a large space at the anterior portion of the kidneys and principally on the left of the center.

The heart sack which surrounds the heart is adherent by loose connective tissue to the sternum or breast bone.

The caeca lay supero-internal to the duodenal fold. The blind extremities lay just anterior to the terminal portion of the loop of the duodenum.

The proventriculus or stomach lays superior to the liver and anterior to the gizzard.

THE COURSE OF THE FOOD.

The food first enters the mouth after being picked up by aid of the beak. From here it passes into the crop without mastication as the bird is not provided with teeth. The crop is a storehouse and by the aid of its muscular walls the food is passed, as needed, through the second portion of the oesophagus to the proventriculus, an expansion in the digestive tube, just before it terminates in the gizzard. The proventriculus is the true digestive stomach, its walls being provided with glands which produce a secretion in which the food soaks before passing into the gizzard. Its reaction is strongly acid. The gizzard is provided with strong muscular walls which, by the aid of grit, thoroughly reduce the food to fineness. From the gizzard the food passes through the first portion of the small intestines where it is subjected to the bile from the liver and pancreatic juice from the pancreas. At the juncture of the small and large intestines there originates two blind pouches called the caeca. From the caeca the food passes through the large intetines or rectum.

Fig. 2—*The Pelvic Organs of the Cockerel:* *a*—the testicles, *b*—the rectum cut off, *c*—the cloaca, *d*—the vas deferens, *e*—the kidney, *f*—the adrenal gland, *g*—the lungs.

THE MALE REPRODUCTIVE ORGANS.

The generative organs of the male fowl are the testes and vas deferens or seminal tubules. In the cockerel, before sexual maturity, the testicles, two in number, are very small, measuring only about one-half inch long and scarcely one-fourth inch in diameter. They resemble, in shape, a navy bean and are yellowish-white in color. Figure No. 2 illustrates the testes. At a and at d may be seen the undeveloped vas deferens or seminal tubule.

Fig. 3—*The Pelvic Organs of the Cock:* *a*—the testicles, showing the delicate capsular covering with its blood vessels, *b*—the rectum cut off, *c*—the cloaca, *d*—the vas deferens which carries the spermatozoa from the testes to the cloaca, *e*—the kidney, *f*—the lungs.

As the male bird becomes sexually active the testicles develop to enormous size, measuring two inches in length and seven-eighths of an inch in diameter as illustrated in Figure 3, which is from a Single-combed White Leghorn Cock one year old.

The testis is made up of a globus major and globus minor or epididymis, the latter is rather rudimentary. The globus major forms the major portion of the testicle. The epididymis is short and from it originates the vas deferens as shown in Figure 3, letter d.

The testicular tissue is made up of secreting tubules in which are formed the spermatozoa (see Figure 4), and a quantity of fluid in which the spermatozoa are transported and an internal secretion.

The testis is surrounded by a thin and delicate membrane which is very vascular as is shown in Figure 3, letter a. The testicles are located just back of the lungs in the region of the adrenal gland and below the anterior portion of the kidney and in front of the three last ribs. They are attached by means of loose connective tissue to the abdominal aorta, veins and bodies of the vertebra.

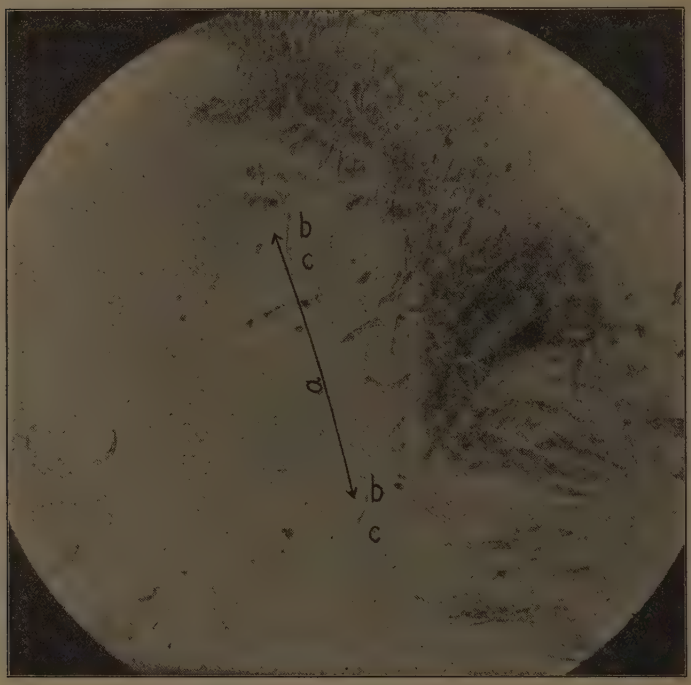


Fig. 4—*The Spermatozoa:* A photomicrograph of a smear from the vas deferens of a Single Comb White Leghorn cock, showing at *a*—two isolated spermatozoa, at *b*—the head and at *c*—the tail. The male element which fertilizes the egg. Magnified 1,000 times.

The tube carrying the fluid or semen from the testis is called the vas deferens and originates at the epididymis which is very short and is located on the upper and inner surface of the testicle. It extends backward and is attached by connective tissue to the roof of the lumbo-pelvic cavity and to the inner side of the kidney. This tube at first is small, but gradually becomes larger and is tortuous in shape as it reaches the cloaca. It empties its contents at the summit of a small eminence in the cloacal mucous membrane.

That an internal secretion is manufactured in the testicles is proven by the physical changes which take place after the testicles are removed. The bird loses his energy, masculine appearance, ambition, and becomes

sluggish. He lays on fat and is hated by both male and females alike. He often shows some femininity in that he will take a brood and mother them. The meat becomes more tender and more palatable. In short the same change is noted as in other animals that have been castrated.

THE GENERATIVE ORGANS OF THE HEN.

The physiological basis of reproduction of the female is the left ovary and left oviduct. The right ovary and oviduct are absent due to the fact that they degenerate during embryonic life.

The ovary is located in the sublumbar region of the abdominal cavity and to the right of the median line and touching the left adrenal gland and just anterior to and below the anterior portion of the kidney. It is located superior to the liver and at the juncture of the abdominal and thoracic cavities. It appears as a cluster of spheres or globe-shaped bodies, which in the adult hen number from 900 to 3,500.

Fig. 5—*The Pelvic Organs of the Pullet:* *a*—the ovary, *b*—the undeveloped oviduct, *c*—the origin (infundibulum) of the oviduct, *d*—the rectum cut off, *e*—the cloaca, *f*—the adrenal gland, *g*—the kidney, *h*—the ureter which carries the urine from the kidney to the cloaca, *i*—the lung.

Figure 5, letter A, represents an ovary of an adult White Wyandotte pullet which ovary has never functionated. The undeveloped ova are noted in a grape like mass. Figure 6, letter A, represents an active ovary from a three pound White Leghorn bantam hen. This hen was developing one egg a day, having laid an egg only three hours before being killed. C represents the yolk of an ovum which would have probably been fully developed in less than twenty-four hours. The ovum is surrounded by a very thin membrane or capsule which is very vascular, as is shown in Figure 6. This capsule is continued back onto the stalk which attaches it to the central fibrous supporting portion of the ovary. This portion is attached to the structures of the back. When the yolk portion of the ovum is fully developed the capsule ruptures and the yolk falls into the first portion of the oviduct or egg canal. This portion of the duct is very thin and gradually merges into a thicker wall

in which portion the mucous membrane is thrown into folds. The yolk is surrounded by a delicate membrane called the vitelline membrane, which holds the mass intact, thus giving it the spherical appearance.

One by one the yolks are developed to full size or to maturity from the mass of undeveloped ova of the ovary as illustrated in Figure 6, letter A. Figure 6, letter B, shows an ovum or yolk reaching full devel-

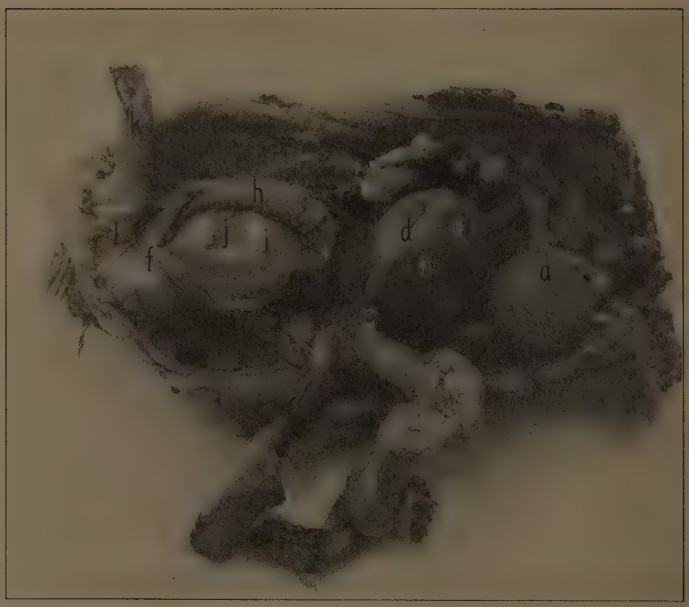


Fig. 6—*The Pelvic Organs of the Hen:* *a*—the ovary, *b*—an ovum nearing maturity, *c*—origin of the funnel shaped portion of the oviduct, *d*—the stigmata or line of rupture which allows the yolk to escape into the oviduct at *c*, *e*—an ovum which has degenerated, *f*—the lower portion of oviduct, *g*—the oviduct which has been torn loose from its ligaments and laid to one side, *h*—the villus-like portion of the oviduct at which point the albumin is forming, *i*—the albumin, *j*—the yolk, *k*—the rectum cut off and laid back, *l*—the cloaca.

opment. Letter D shows a nonvascular line, the stigma, where the follicular wall is becoming thin preparatory to discharging the yolk into the oviduct. The discharge of the yolk into the oviduct is sometimes spoken of as ovulation.

The yolk has its origin in a minute sphere containing a nucleus as illustrated by Figure 7, letter A. This nucleus marks the point of the development of the embryo chick after fertilization. It is noted to be located in the central portion. When the cell begins the development of the yolk, there is noted first a deposit of fine granules of yolk around the central nucleus, letter B. These granules of yolk material gradually extend towards the cell walls. This deposit is known as the latebra or the flask-shaped mass of white yolk. Later when the ovum has reached the size of about 0.66 millimeters in diameter the nucleus is

noted to occupy a position just under the vitelline membrane and at the end of the flask-shaped mass as illustrated in Figure 7, letter C.

Later several layers of yellow yolk are deposited around the central mass of white yolk which is apparently brought about through the secretion of the peripheral layer of protoplasm.

FIG. 7—*A Section of the Ovary of a Hen:*—*a*—a cluster of four quiescent ova, showing the cell walls, nuclei and cytoplasm, *b*—a cell in which the deposition of yolk has begun pushing the nucleus to one side of the cell, *c*—a later stage of the yolk formation. A photomicrograph of a stained section, magnified 100 times.

The spermatozoa, Figure 4, make their way, by aid of terminal flagella or tails through the oviduct and fertilization takes place as soon as the yolk has entered the oviduct. Only one spermatozoon is utilized in this fertilization process. The balance are repelled from the cell.

After the yolk passes into the oviduct albumin is formed around it in the upper two-thirds of the duct by specialized columnar epithelial cells.

The contraction of the muscles of the oviduct force the contents along. When the albumin formation is completed the newly forming egg passes into the isthmus where through the activity of other specialized cells a membrane is formed around the mass.

In the lower portion as illustrated in Figure 6, letter B, the calcium layer or shell is formed to protect the delicate mass within from external violence.

The formation of the albumin around the yolk in the upper two-thirds of the oviduct is probably accomplished in about three hours. The membrane surrounding the egg mass is formed in the isthmus in about the same length of time. The formation of the shell and the expulsion of the egg will be accomplished in from twelve to eighteen hours.

The yolk is of less specific gravity than the albumin, hence it gradually rises to the top, carrying with it the blastoderm on its upper side. See Figure 8, letter a. If allowed to remain in this position the blastoderm may become adherent to the egg membrane and thus cause death of the embryo, hence the necessity of turning the eggs for hatching and during the first eighteen days of incubation.

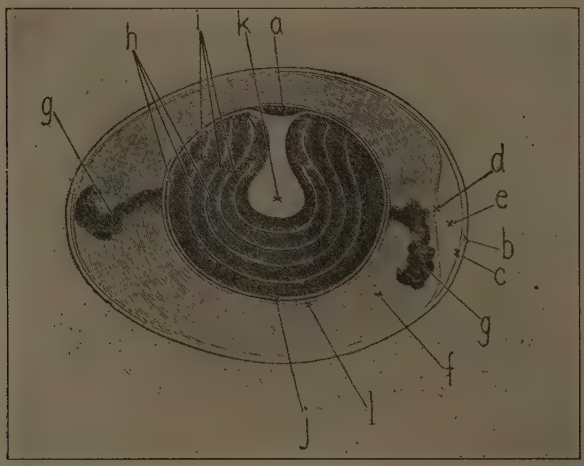


Fig. 8—*Diagramatic Structure of the Egg: a*—the blastoderm, *b*—the shell, *c*—the outer shell membrane, *d*—the inner shell membrane, *e*—the air cell at the large end, *f*—the albumin, *g*—the chalaza, *h*—the dark yolk, *i*—the white yolk, *j*—the vitelline membrane, *k*—the flask-like white yolk, *l*—a fluid albuminous layer which immediately surrounds the yolk.

It would rather indicate that there is just as high a production of eggs from an individual without the service of a male as with such service. In other words the spermatozoa have no influence in the rate and number of the development of eggs.

The egg, as laid, consists of an outer shell coating giving it a gloss or so called bloom which may be considered as a protective coat. The shell consists largely of lime salts. There is an outer shell membrane located just inside the shell and an inner membrane which dips across at the large end of the egg and forms the air cell. (Fig. 8, letters c and d.) This membrane consists of a fibrous structure, the fibers of which extend in all directions. The air chamber becomes larger as incubation goes on, in order to meet the respiratory needs of the embryo or as we may say, the fetus. The head is almost invariably developed in the large end of the egg if it lies on its side. The albumin is appropriated for the formation of the embryo chick.

Immediately surrounding the yolk there is a dense layer of albumin and outside of this a less dense layer.

The albuminous portion (egg white) consists of 86.2 per cent water, 13 per cent proteid, 0.2 per cent fat and 0.6 per cent ash and possesses a caloric value of 265.

The hen egg corresponds to the ovum of higher animal life where, after fertilization of the ovum, development of the fetus takes place normally in the uterus of the mother. Said ovum is made up of a male and a female procucleus as in the hen egg and protoplasm and deutoplasm, the deutoplasm being nutriment for the embryo till it has developed sufficiently to draw on the nutrients of the blood from the mother's

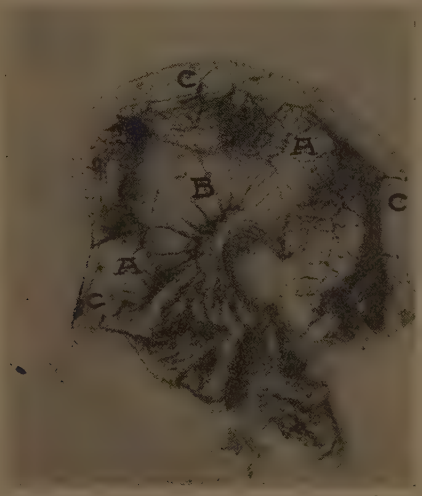


Fig. 9—*Oviduct of a Laying Hen:* *a*—the oviduct, *b*—the inferior ligament, *c*—the superior ligament of the oviduct.

uterus. In the case of the bird there is no uterus in the sense that we speak of it in higher animal life. Nature has been elaborate in storing up food for the embryo and the baby chick for the yolk is apparently almost wholly intended to be drawn upon the first seventy-two hours of the baby chick's life or until hatching of the brood is over and till it is strong enough to follow the mother. An examination of a newly hatched baby chick will show this yolk in the abdominal cavity and much still unabsorbed.

The active or functionating oviduct is a rather large, tortuous tube varying in size and length according to the size of the hen and filling a large part of the left half of the abdominal cavity, as illustrated in Figure 6. In a White Plymouth Rock pullet weighing five pounds and whose ovary and oviduct had not yet become active the oviduct measured but five inches. See Figure 5, letter B. The functionating oviduct may be seen in Figure 6. This duct is held in position by a superior and an inferior ligament, as shown in Figure 9.

It can readily be seen that in a very fat hen with the intestines, liver and other organs and a functionating ovary and oviduct as illustrated in Figure 6, the abdominal cavity would be crowded. When this crowded condition arises there may be a partial or complete cessation of the function of the ovary and oviduct. The hen then ceases to lay.

The oviduct originates at the anterior portion at the abdominal cavity, Figure 6, letter C, by an expansion of the ovary in such a way as to receive the yolk when it is discharged from the yolk sack of the ovary. This portion is anatomically known as the funnel, ostium abdominale or infundibulum. The oviduct may be divided into five portions as follows: the principal albumin secreting portion, a more constricted portion, the isthmus, the shell gland portion sometimes referred to as the uterus and the outer passage, by some known as the vagina. The vaginal or outer portion of the oviduct is guarded by a rather well developed sphincter muscle. The oviduct is attached to the surrounding structures by dorsal and ventral ligaments. See Figure 9.

The oviduct consists of three main coats, namely: An external serous, a middle muscular (being made up of an outer longitudinal and an inner circular layer), and an internal mucous coat which is thrown into rouge or folds both primary and secondary, and provided with columnar epithelial cells. The oviduct has great power of dilitation but tears easily if the traction is too much in one direction. A ruptured oviduct sometimes occurs.

LABORATORY WORK

The Animal Industry Division of the North Carolina Experiment Station at West Raleigh, has thoroughly equipped the Poultry Investigation and Pathology Laboratory. This laboratory will make examinations of parasites and specimens of tissue from diseased birds.

In sending material to the laboratory, external parasites should be placed in a dry bottle, and worms from the intestines should be placed in a bottle containing a 10 per cent solution of formalin (which can be obtained at a drug store). The bottle should be packed in cotton in a wooden box and sent by parcel post. Larger specimens of tissue must be fresh, carefully washed in clean water and placed in a fruit jar in a 10 per cent solution of formalin. A rubber band should be used, so as to prevent leakage from the jar. The jar must contain at least as much liquid as a specimen, that is, the specimen should not fill the jar more than half full. This jar should then be carefully packed in a box, using excelsior or cotton seed hulls as packing, and sent by prepaid express. A letter should be sent the same day giving full particulars as to the symptoms and history of the case.

If it is suspected that the bird has died of a contagious disease it should be picked and the whole bird, or its essential organs, placed in a jar of glycerine instead of formaldehyde. If this be done a bacteriological test can be made.

A Corner in the Office of Poultry Investigations and Pathology, Animal Industry Division, North Carolina Experiment Station.

NOVEMBER, 1915 BULLETIN 234

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE

AND THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

RALEIGH AND WEST RALEIGH

Farm Drainage in North Carolina

By H. M. LYNDE

Senior Drainage Engineer of United States Department of Agriculture

---

Bulletins of the Station Will be Sent Free to Citizens of the State on Request

THE NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE

AND THE

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

BOARD OF AGRICULTURE

*W. A. GRAHAM, *Chairman*, Raleigh.

F. P. LATHAM.....Belhaven	*A. T. MCCALLUM.....Red Springs
C. W. MITCHELL.....Aulander	*C. C. WRIGHT.....Hunting Creek
*R. L. WOODARD.....Pamlico	WILLIAM BLEDSOE.....Gale
*CLARENCE POE.....Raleigh	W. J. SHUFORD.....Hickory
R. W. SCOTT.....Haw River	A. CANNON.....Horse Shoe

BOARD OF TRUSTEES OF THE COLLEGE

GOVERNOR LOCKE CRAIG, *Chairman.*

M. B. STICKLEY.....Concord	*T. T. THORNE.....Rocky Mount
T. T. BALLINGER.....Tryon	*C. W. GOLD.....Greensboro
W. H. WILLIAMSON.....Raleigh	T. E. VANN.....Como
O. L. CLARK.....Clarkton	P. S. BOYD.....Mooresville
EVERETT THOMPSON.....Elizabeth City	W. E. DANIEL.....Weldon
R. H. RICKS.....Rocky Mount	*W. H. RAGAN.....High Point
O. MAX GARDNER.....Shelby	W. B. COOPER.....Wilmington
M. L. REED.....Biltmore	J. P. MCRAE.....Laurinburg

*D. H. HILL (President College), West Raleigh.

STATION STAFF

B. W. KILGORE.....Director	[1]J. M. JOHNSON.....Farm Management
C. B. WILLIAMS..Vice-Director, Agronomist	F. R. BAKER..Assistant Drainage Engineer
W. A. WITHERS.....Chemist	R. O. CROMWELL..Assistant, Plant Diseases
FRANKLIN SHERMAN, JR.....Entomologist	[3] A. J. REED.....Dairy Farming
W. N. HUTT.....Horticulturist	STANLEY COMBES, Assistant, Dairy Farming
G. A. ROBERTS.....Veterinarian	F. S. PEDEN.....Beef Cattle
[1] C. R. HUDSON.....Farm Demonstration	[3] J. B. MCVEAN.....Pig Clubs
J. P. PILLSBURY.....Horticulturist	[3] J. A. AREY.....Dairy Farming
H. R. FULTON.....Plant Diseases	[2] A. L. JERDAN.....Beef Cattle
Z. P. METCALF.....Entomologist	[3] A. G. OLIVER.....Poultry Clubs
DAN T. GRAY.....Animal Husbandry	EARL HOSTETLER,
W. R. CAMP.....Marketing	Assistant, Beef Cattle and Swine
J. M. PICKEL.....Feed Chemist	[3] F. R. FARNHAM, Assistant in Dairy Farming
W. G. HAYWOOD.....Fertilizer Chemist	W. C. NORTON....Assistant in Bacteriology
L. L. BRINKLEY.....Soil Survey	[1] T. E. BROWNE, Asst. in Charge Boys' Clubs
R. G. HILL.....Assistant Horticulturist	[1] A. K. ROBERTSON.....Asst. in Boys' Clubs
[2] W. E. HEARN.....Soils	[1] MRS. C. MCKIMMON,
R. S. CURTIS..Associate in Animal Industry	Assistant in Charge Girls' Clubs
J. K. PLUMMER.....Soil Chemist	[1] MISS M. L. JAMISON,
S. C. CLAPP.....Assistant Entomologist	Assistant in Home Economics
W. H. EATON.....Dairy Experimenter	E. B. HART.....Assistant Chemist
[1] E. H. MATHEWSON.....Tobacco Expert	F. E. CARRUTH.....Assistant Chemist
J. Q. JACKSON.....Assistant Chemist	F. B. SHERWOOD.....Assistant Chemist
L. R. DETJEN.....Assistant Horticulturist	B. SZYMONIAK,
A. R. RUSSELL..Asst. in Field Experiments	Demonstrator in Fruit and Truck Crops
R. Y. WINTERS.....Plant Breeding	C. D. MATTHEWS...Assistant Horticulturist
B. F. KAUPP,	F. N. MCDOWELL.....Soil Survey
Poultry Investigator and Pathologist	R. W. LIEBY.....Assistant Entomologist
W. F. PATE.....Agronomist—Soils	D. T. MCCARTY.....Assistant Chemist
E. C. BLAIR...Assistant Agronomist—Soils	F. C. WIGGINS.....Assistant Chemist
E. S. DEWAR.....Assistant Chemist	F. H. JETER.....Agricultural Editor
[4] H. M. LYNDE....Senior Drainage Engineer	MISS MARY S. BIRDSONG..Sec'y to Director
	A. F. BOWEN.....Bursar

R. W. COLLETT.....Assistant Director Branch Stations
F. T. MRACHAM.....Assistant Director Iredell Branch Station, Statesville
J. H. JEFFERIES.....Assistant Director Pender Branch Station, Willard
C. E. CLARK.....Assistant Director Edgecombe Branch Station, Rocky Mount
[1] E. G. MOSS.....Assistant Director Granville Branch Station, Oxford
S. O. PERKINS.....Assistant Director Buncombe and Transylvania Stations, Swannanoa

---

The members marked with * are members of the Joint Committee for Agricultural Work, and the Station is under their direction.

[1] In coöperation with the U. S. Department of Agriculture, Bureau of Plant Industry.
[2] In coöperation with the U. S. Department of Agriculture, Bureau of Soils.
[3] In coöperation with the U. S. Department of Agriculture, Bureau of Animal Industry.
[4] In coöperation with the U. S. Department of Agriculture, Office of Public Roads and Rural Engineering.

CONTENTS

	PAGE
Introduction	5
What Lands Need Drainage	5
The Water in Soils	7
The Open Ditch	8
The Underdrain	8
Benefits of Drainage	9
Tile Drainage	11
Clay Tile	11
Concrete Tile	11
Arrangement of Drains	12
Depth and Spacing	15
Grade	16
Size of Tile	16
Construction of Tile Drains	18
Outlet Ditches	18
Laying Out the Drains	18
Digging the Ditch	20
Grading the Bottom of the Ditch	21
Laying the Tile	26
Backfilling	27
Protection of Outlets	27
Surface Inlets and Silt Wells	29
Obstructions in Drains	29
Vertical Drainage	30
Cost of Tile Drainage	30
Will Tile Drainage Pay?	31

ILLUSTRATIONS

PAGE

PLATE I, FIG. 1. Undrained Land, State Test Farm, Willard, N. C. (August, 1910) 6

FIG. 2. Cowpeas and Corn on Same Land After Tile Drainage. Corn in Place of Timber (August, 1913) 6

PLATE II, Setting Cross-bars to Support Grading Line 22

PLATE III, Testing Grade by Use of Grading Line and Rod 23

PLATE IV, Finishing Grade with Tile Scoop 24

PLATE V. Laying Tile with Tile Hook 25

FIG. 1. Effect of Tile Drainage on Growing Crops 9

FIG. 2. Arrangements of Drains 13

FIG. 3. Proposed Tile Drainage Systems on Farm near Washington, Beaufort County, N. C. 14

FIG. 4. Proposed Tile Drainage Systems on Farm near Tarboro, Edgecombe County, N. C. ..... *Facing page* 19

FIG. 5. Profile of a Tile Drain 19

FIG. 6. Tools Used in Constructing Tile Drains 20

FIG. 7. Correct and Incorrect Grading 26

FIG. 8. Tile Outlet, Screen Gate, and Pipe Inlet 28

Farm Drainage

Introduction.

Farm drainage is one of the most important agricultural operations with which the farmer in North Carolina has to deal. Drainage lies at the basis of successful agriculture in the Coastal Plain Region, which comprises an area of over 14,000,000 acres—nearly one-half the total area of the State. Everywhere in this section the need of drainage is evidenced by the large number of open ditches on nearly every farm. Most of the land is gently rolling or flat, underlain by a clay subsoil, and the natural underdrainage is usually poor. In the Piedmont and Mountain Regions every farm has its shallow ditches through hollows or depressions to drain these places. Thus, the subject of farm drainage is statewide in its importance. It has been estimated that from five to six million acres of land now under cultivation in the State are in need of better drainage.

The drainage of our swamps in the Coastal Plain Region, and of our overflowed creek lands in the Piedmont Section, has progressed at a rapid rate since the passage of a state drainage law in 1909, and probably no other State in the South is so far advanced in the development of these areas as is North Carolina; but the solution of these larger drainage problems is but the preliminary work of drainage, for is it not true that the ultimate end of all drainage improvements is the drainage of the individual farm?

Many landowners in the eastern part of the State take it as a matter of course to be "drowned out" about once in every four years, and in the intervals between such floodings the land may seem well drained, since no water stands on the surface during most of the crop season. It is not well drained, however; it needs better soil drainage, which is a matter not related to swamps, nor is it the mere removal of surface water. "The basis of good soil management is a correct water supply, not too much nor too little, but the right amount at the right time."

In response to the large number of inquiries to this Station concerning drainage, and owing to the increasing interest manifested in this subject, it has seemed appropriate to issue a bulletin at this time. In addition to emphasizing the general need for better farm drainage in this State, this Bulletin deals with the underlying principles and practice of this subject.

What Lands Need Draining.

The general impression is that only land upon which water stands for a considerable length of time needs drainage. Such a condition, however, simply means that the water has risen from below to the surface,

Note.—In accordance with an agreement between the U. S. Department of Agriculture and the North Carolina Department of Agriculture, the Federal Department has for several years maintained in North Carolina a drainage engineer who is assisted by an engineer provided by the State Department of Agriculture, for the purpose of promoting the practice of farm drainage in this State. This Bulletin has been prepared under this coöperative agreement.

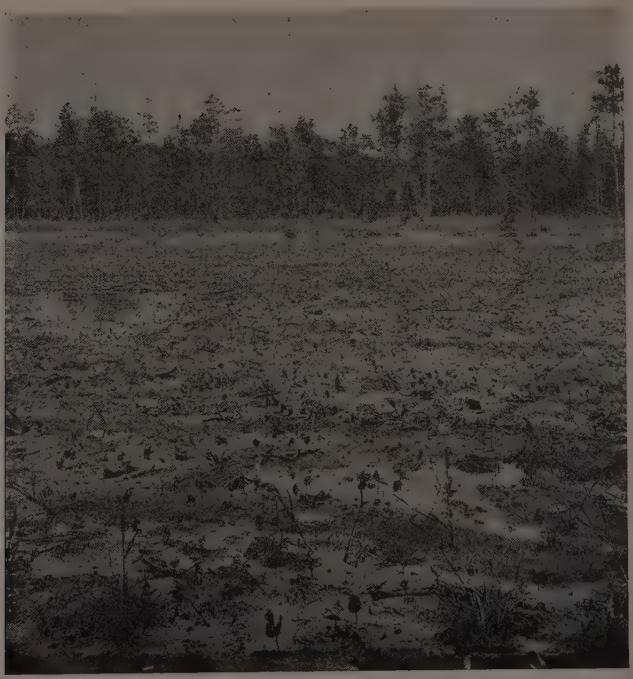


Plate I, Fig. 1. Undrained land, State Test Farm, Willard, N. C. (August, 1910). (Cowpeas after two plantings of corn the preceding spring.)

Plate I, Fig. 2. Cowpeas and Corn on the Same Land After Tile Drainage. Corn in Place of Timber (August, 1914).

and that the ground is completely saturated. The water may gradually disappear from the surface, but this does not mean that the land is drained, as the water in the soil still remains. The water level may fall so slowly and be so close to the surface that the soil cannot be ploughed for several days. By using a soil auger the depth of the water table can be ascertained. If this water level is found to stand, for weeks at a time, too close to the surface (say within 1, 2, or even 3 feet) it will interfere with crop production.

Throughout the eastern section of the State the land is flat or gently rolling; much of it is underlain by a clay subsoil, and the run-off is very slow. The storms occurring are often intense and the capacity of the soil is overtaxed. There is no question as to the fertility of the soil, for fair crops are produced in average seasons and good crops in dry seasons. Probably on many of the farms there is no complete loss of a crop in any season, but the possibility of being unable to get a good crop started without an unnecessary amount of work is always present.

In the upper Coastal Plain Region are many depressions without natural outlets, in which water collects and escapes only by evaporation or slow percolation. By the installation of a single line of tile with a surface inlet such places can often be made the most profitable parts of the farm. In this same section, just east of the dividing line between the Coastal Plain and Piedmont Regions, are hill areas whose surface slopes would indicate their drainage to be adequate, but whose peculiar soil structure renders drainage defective. This consists in a relatively porous topsoil, usually to the ploughed depth, underlain by a very impervious subsoil or hardpan. In many places the overlying soil is seepy or springy. Sloughs and depressions in all parts of the State need draining in order that they may be cultivated. Our creek bottom lands need drainage. Many soils whose surface drainage is good require better soil drainage; and many types, such as those of our flat areas, whose capacity for taking care of water is good if only the excess were removed, need attention also.

The principal function of artificial drainage is to remove a sufficiently large proportion of the excess water which accumulates during the most rainy periods to insure that the soils or crops shall not suffer injury. A drainage system should be so designed that at no point will the water stand upon growing crops for much more than a day. Furthermore, the water level in most soils should be lowered to a depth of 3 feet below the surface within a reasonable length of time after a period of heavy rain.

The Water in Soils.

From the standpoint of drainage, there are two kinds of water in the soil: (1) gravitational or hydrostatic water, and (2) capillary water.

Gravitational water is the excess water in the soil which tends to obey the laws of gravity by moving downward. When this water fills the pores of the soil up to a level close to the surface of the ground, injury is done to the plants. The presence of air in the soil is as essential as is the presence of water.

The water that is used by plants, and all that they require, is the water that moves upward through the soil in the same manner that oil is

drawn through the wick of a lamp. This is called capillary water, and it is moved only by so-called capillary attraction. Its supply is constantly replenished by the hydrostatic water below. A well-drained soil is like a sponge or piece of blotting paper. When placed in water a sponge will absorb a large amount, and when taken out the excess, or hydrostatic water, will run off; the water remaining in the sponge is capillary water, and is removed only by evaporation. In a drained soil this capillary water is removed by evaporation or is taken up by the roots of the plants and transpired through the leaves. It should be understood at the outset that drainage does not remove any water that would be beneficial if it remained. It simply removes the static, or free water. It has been stated by an authority that "of the from 30 to 60 per cent of moisture which soils can hold, it is possible to remove only one-half by drainage. The loss of this quantity leaves open air spaces in the soil, although it still contains 15 to 30 per cent of its own volume of water. Plant growth requires as much moisture as this in the soil; more than this is too much; less is too little."

In order to replenish the supply of soil moisture the surplus water should be carried first down through the soil, and then off. The two means generally employed to accomplish this are the open ditch and the underdrain.

The Open Ditch.

The open ditch has its place in all drainage work, but in farm drainage its principal use is, or should be, as an outlet for tile drains. In sandy soils ditches are perhaps as efficient as tile drains, but in heavy clay or loam soils they afford only imperfect soil drainage. The flow of water and the frequent cleaning necessary in a clay ditch tend to seal the pores of the soil in the banks, and thus impede the passage of water into the ditch. When this happens, a large portion of the water flows over the surface, rather than down through the soil and then off, as it should in order to be available to replenish the supply of capillary, or useful water.

The common surface ditches are, from an agricultural standpoint, expensive and of low efficiency. Often they are not deep enough, their grades are usually poor, and the water flows slowly. The ditches mar the surface, cut the farm into irregularly shaped fields, interfere seriously with tillage, and harbor weeds. The actual space they occupy amounts to from 4 to 10 per cent on many farms. Often they are not spaced closely enough to give good drainage, because they are in the way. Furthermore, they must be cleaned out from year to year. All of these features tend to make open ditches more expensive over a long period of time than are underdrains.

The Underdrain.

Poles, plank, brush, and stone have been used for underdrains; and, where intelligently applied, have given good service while they lasted. Usually, however, the length of time that such drains give good service is short, either by reason of the decaying of the wood or from the accumulation of silt. Undoubtedly, the best type of underdrain is tile.

In a tile-drained field nearly all the water passes down through the ground, thus replenishing the moisture in the soil. A line of tile laid in the ground provides an open and efficient channel. It does not act until the soil below the level of the bottom of the tile is completely filled with water; then all the water entering the soil above this point gradually finds its way to the tile. If it were not for the resistance of the soil particles all the water would be brought to the tile quickly, but because of this resistance the water nearest the tile finds its way there first, and is followed by that further away; consequently, between the lines of tile the water table forms a curve, highest in the middle (see Fig. 1), which gradually becomes flatter as the water is removed.

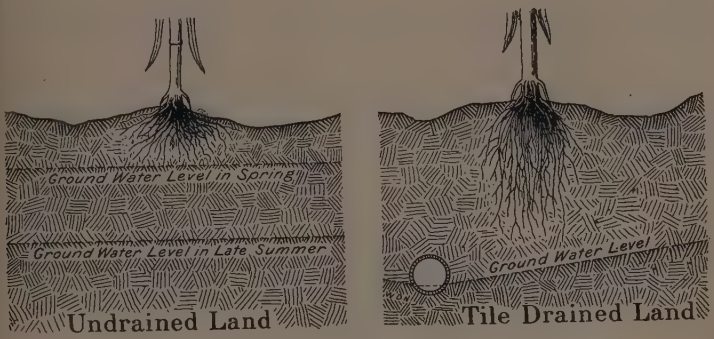


Fig. 1. Effect of Tile Drainage on Growing Crops.

Benefits of Drainage.

Thorough drainage of the soil changes both its mechanical and its chemical structure; as an effect of these changes, come the practical results expected by every one who drains. The first effect of the removal of surplus water from the soil is aeration, or the admission of air into the spaces previously filled with water. As a result of this aeration of the soil, most of the other benefits of drainage naturally follow, the most important of which are as follows:

Soil is Deepened. No roots except those of aquatic plants will grow in stagnant water. By lowering the water table the air is allowed to circulate through the soil above, making the texture more open; and it is only in soil in which both air and water circulate that roots of cultivated crops grow.

Root Zone is Enlarged. By deepening the soil the roots are enabled to extend both downward and laterally, and crops thus start a healthy growth as soon as planted, and their development is not restricted by a high level of ground water. Experiments have shown that grains, grasses, and other plants will extend their roots to a depth of three or more feet if unobstructed. The time when the most drainage is needed is in the spring when the root system is developing. Fig. 1 illustrates this point. In undrained land the ground water during the

spring is near the surface, therefore the plant roots spread out flat. Thus, later in the season, when the level of the ground water lowers, the plant is left to "burn." In tile-drained land the soil becomes loose and friable, and retains only such moisture as can be held and used by the plant; the roots therefore develop downward, where they reach and utilize all the moisture and plant food the soil contains.

Pulverization is Assisted. Ploughing clayey soil when wet tends to press it together, or puddle it, and to make it less pervious to water; or, if it is partially dry, it will break up into clods which only become harder as they dry out. As a result of thorough drainage, this same land becomes lighter to work, breaks up into smaller pieces, and is cultivated more easily.

Soil is Made Firmer. How often do we hear the expression, "The land is too soft to cultivate." Thorough drainage fills the pores with the correct amount of moisture and air and takes away the excess water, the result being that, while the soil is lighter, it is nevertheless more stable than when wet, and no damage results from driving a heavy load upon it.

Surface Washing is Prevented. With a soil completely saturated, the only escape for the rainfall is over the surface, carrying with it the rich soils and fertilizers of the higher land and depositing them in the depressions. When thoroughly drained, the water passes down through the soil, carrying with it the plant food contained in fertilizers and placing it where it is available to the plants' use. On steep land where surface washing is caused by springs, a line of tile to carry off this water will prevent gullying.

Temperature of the Soil is Raised. Water is very much more difficult to heat than is the solid matter of the soil. Authorities state that it requires about ten times the amount of heat to raise the temperature of a given volume of water to a desired figure as is required to raise that of an equal volume of soil particles the same amount. The more water there is in the soil the more heat is lost in evaporation. Hence, the less the water in the soil the more quickly the latter is warmed. The open texture of a drained soil also allows the warm rains of spring to pass downward through it, thus warming the soil.

Growth of Desirable Organisms is Assisted. The conditions of an abundance of air and a proper amount of moisture and warmth in the soil—which conditions are brought about by drainage—are the environment most favorable to the growth of desirable organisms which are necessary for the best condition of plant growth.

Replanting is Avoided. At the first favorable opportunity in the spring the farmer plants his seed. A rain may come and saturate the soil, if it is not well drained, before the seed has a good start. Thus the seed is either washed away or rotted, and the work of planting has to be repeated. On thoroughly drained soil only a very severe storm will necessitate replanting.

Drought is Resisted. Owing to the large and deep root zone resulting from drainage, the root system is in better condition to withstand a drought when it comes, as the available space from which the roots can absorb capillary water is enlarged, and the roots will have penetrated to a level nearer the permanent water supply.

Freezing Out is Prevented. Water freezing in a saturated soil expands, and in expanding lifts the soil, carrying small plants with it. This is called "heaving." Repeated heaving often causes plants to be thrown entirely out of the soil. This frequently causes the "winter killing" in winter crops.

Health Conditions Are Improved. By the removal of dampness from the atmosphere and the destruction of the malarial mosquito, which breeds in stagnant ponds, slow-running ditches, etc., the health conditions may be greatly improved. Besides the benefits to man's health, there can be expected a corresponding decrease in sickness among farm animals.

Tile Drainage.

The form of drainage most likely to lead to all of the benefits above enumerated is underdrainage, and the best material for underdrains is tile. Tile drainage is accomplished by lines of tile laid at proper depths and intervals, the tile being of sizes sufficient to carry away all the water coming to them before the soil is injured by saturation. Drain tile are ordinarily made either of burned clay or concrete.

Clay Tile.

Clay tile may be either soft or hard burned, or vitrified. The hard burned and vitrified tile are the most durable, because they are stronger, and as the walls are less porous they are more resistant to frost action. The drainage efficiency of tile is not affected by the porosity of the walls. The walls of a porous tile will absorb water quickly until saturated, but beyond that no appreciable amount of water passes through the walls. It has been proved by experiment, that the porous property in tile has no value for draining. The water enters the tile through the joints.

In the early history of tile drainage, tile were made of various shapes, prominent among which was the horse-shoe tile with a flat bottom, either open or closed. These have long been superseded by the cylindrical tile, that is, tile with a round bore. The most common form of tile is round both outside and inside, although considerable tile in use at the present time has a hexagonal outer surface.

Concrete Tile.

Concrete tile have come into use in more recent years and are extensively employed in the Middle West. If properly made, they are probably as good as clay tile. However, we have as yet little data as to their adaptability for long continued use. Failures have occurred, but so, also, have they in clay tile. Some of the arguments advanced in favor of concrete tile are: That they can be manufactured where they are to be used; that they are more smooth and uniform in shape than are clay tile, and that, because they can easily be made porous, water will readily pass through the wall, and hence drain the land more thoroughly. However, as has just been stated, the results of experiments with porous clay tile show that the porosity in tile is of no value in underdrainage;

on the contrary, porosity of concrete tile is evidence of weakness and poor quality. Good concrete tile, like good clay tile, should ring when struck with a hard substance.

With concrete tile, so-called failures that have occurred can generally be traced to unsuitable materials, poor or ignorant workmanship, or improper curing. The leading cement manufacturers recommend that tile be made of a rich mixture, and be as nonporous as possible. In order to make dense, impermeable concrete tile, the aggregate used must consist of inert material which is clean, hard, and durable, as well as free from all deleterious matter, and well graded in size of materials from fine to coarse. Sufficient cement must be used in the concrete mixture to completely fill the voids in the aggregate. With a first-class sand having a maximum size of particles of one-quarter inch, this requires a mixture not leaner than one part of Portland cement to three parts of sand. Sufficient water must be added to this dry mixture to permit complete hydration of the cement. No amount of additional wetting after the mortar has hardened will compensate for a mixture originally made too dry. When tile are removed from the machine they should show watermarks on the interior surface. Tile which do not show these markings are being made too dry.

Special care should be used in curing, as a well-made tile may be ruined by improper curing. In order to prevent evaporation from the thin walls of the tiles, they should be covered with some material like straw or bags, and be frequently sprinkled with water for at least a week. Concrete tile should not be used for at least a month after manufacture. The steam process is the best method of curing tile, and also accelerates the hardening.

It is difficult to make satisfactory concrete tile on the farm because of the lack of adequate facilities. The best place for them to be made is in a factory where all the facilities for proper mixing, molding, and curing are at hand. Compared with that of clay tile, the cost of concrete tile, if properly made at a factory, is about the same in this State.

Arrangement of Drains.

The arrangement of the drains is determined largely by the topography of the land, although for level land there are several recognized systems which should be more or less closely followed to secure the most drainage for the least cost. In general, the main should take the same general route as the water takes, in a wet time, in passing off the land. As far as possible, laterals should be straight, and should run in the general direction of the greatest slope. They should be arranged in more or less parallel lines at such intervals as will accommodate the soil. A system of short mains with long laterals is one of the most economical ones that can be secured, because each main and submain drains the land for a certain distance on each side of it, and the laterals passing through this zone serve principally in conducting the water to the main; in other words, the land adjacent to the mains is double drained. To eliminate this as much as possible, the laterals should, where practicable, discharge into the mains on one side only. One main should serve as many laterals as possible, so as to avoid an unnecessary number of outlets, which always require more or less attention.

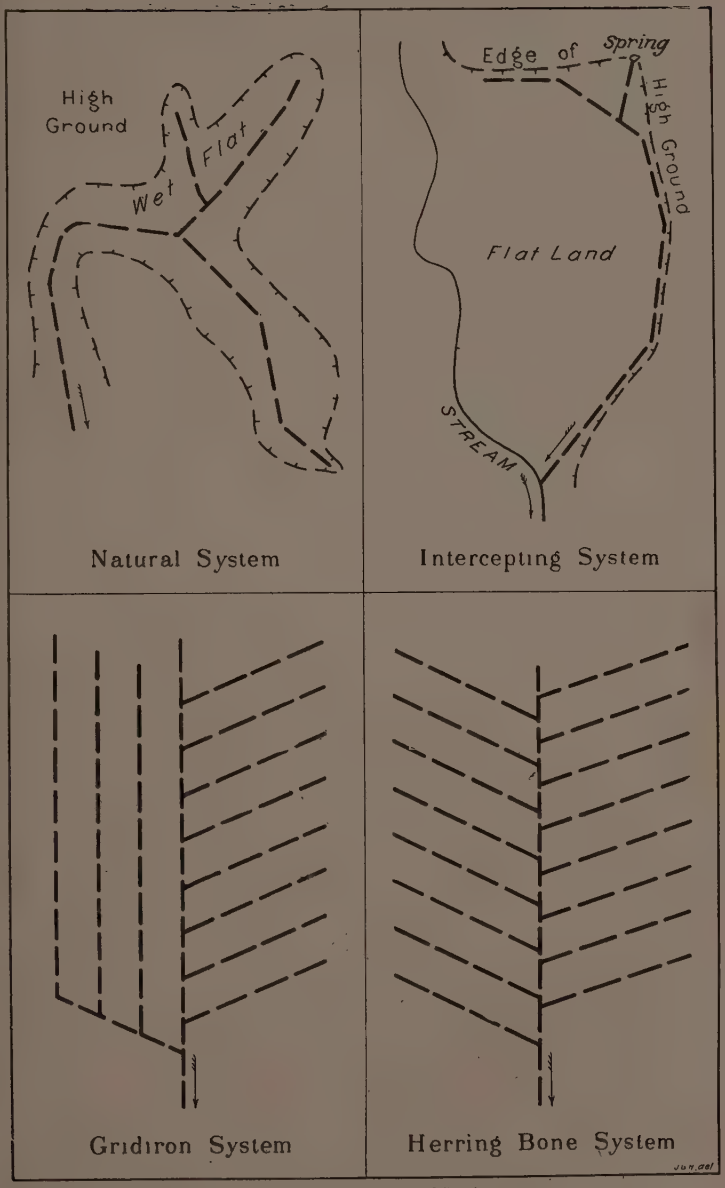


FIG. 2. Arrangements of Drains.

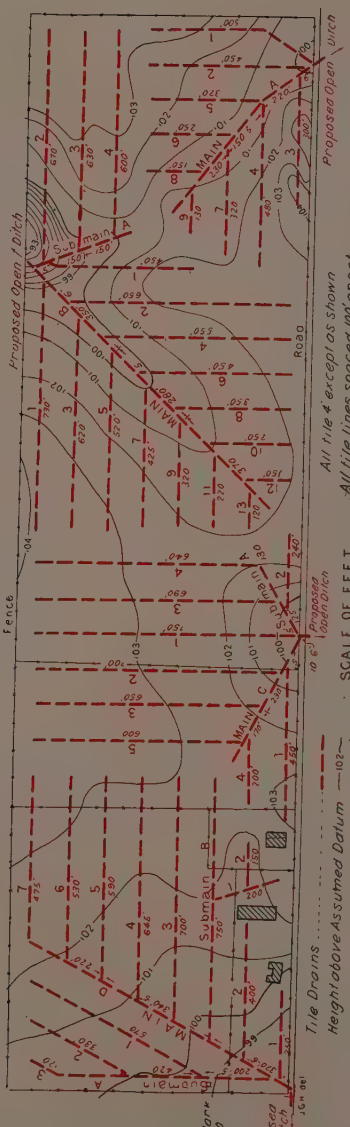


FIG. 3. Proposed Tile Drainage System on Farm near Washington, Beaufort County, N. C.

The arrangements of drains most generally used are the so-called natural, gridiron, and herring-bone systems; these are illustrated in Fig. 2. The natural system is used to drain hollows and depressions where the whole tract does not need drainage, and the lines are usually more or less crooked since they follow the lowest portions of the depressions. In uniform drainage, these lines in the depressions are usually the mains or submains.

In the gridiron system the laterals lie on one side of the main. This is one of the most economical systems that can be used in draining level lands, since the land on only one side of the main is double drained.

The herring-bone system consists of a main with laterals entering it on both sides, like the bones of a fish. This system is necessary where the main is laid in a depression and the fall is slight. While the land on each side is double drained, yet it will be so drained only where it is wettest, and this feature may be of benefit in those places where it is necessary to use this system.

In addition to the above, there is what is known as the intercepting system, which is used in draining broad, flat areas which are wet because of seepage from the adjoining hillsides. The idea in such cases is to intercept the flow at the base of the hill land. This plan is also sometimes used in draining springy hillsides, by placing the tile above the outlets of the springs to cut off the water supply. If the exact location of the spring be determined it can be drained by tapping it directly, otherwise it is best to cut off the supply by an intercepting drain.

While the arrangements described cannot be followed strictly in all cases, and will have to be modified more or less by local conditions, yet it is well for the landowner to keep them in mind if he wishes to secure the most drainage at the least cost. All land is naturally divided into drainage units, in each of which one or more of these different systems can be used to advantage. Above all, tile should not be installed in a haphazard manner, but the whole system should be planned first and then such portions installed as seem at the time advisable; these portions can be added to later on, so that they will ultimately form links in the completed system. Generally, it will be found true economy to procure the aid of an experienced engineer, if convenient, to lay out the work at the outset. In this way, not only will the most economical arrangements of drains be secured, but inaccuracies in the grades will be avoided. Fig. 3 shows complete drainage for a farm of 57 acres, in which both the gridiron and herring-bone systems are used.

Depth and Spacing.

The depth of drains and their distance apart will be largely determined by the texture of the soil. With regard to depth, from 4 to 4½ feet is called deep, 3 feet medium, and from 2 to 2½ feet shallow. It has been explained that the ground water level is lowered between the lines of tile in a curved line, the highest point being midway between the drains, and the lowest point directly above them. The distance apart and depth should be such as to reduce the ground water table between the tile lines to a level most beneficial to plant growth, within twenty-four hours after the ground has been saturated.

In sandy land the drains may be placed deeper than in clay land, and with this increase in depth may be spaced farther apart. In clay land an increase in depth of tile will not usually permit an increase in the spacing, because the sluggishness of soil-water movement in clay soils would cause the water level to be lowered too slowly for the best results to the crops. Except in very stiff soils, a shallow depth is not recommended, however, because, while shallow drains would perhaps give better drainage for the first few years, yet as time goes on the texture of the soil becomes more open, and deeper drains would then be desirable.

In North Carolina, except in the more stiff soils, like pipe clay, an average depth of 3 feet will usually give good results for general field crops. A spacing closer than 60 feet makes drainage so costly that it is not recommended except on valuable land. A spacing of 100 feet is giving good results on the Portsmouth soils in the Coastal Plains Region. For trucking crops a closer spacing is necessary than for general field crops. As a basis for the proper spacing of drains, Elliott states the following for the different types of soils: Close, dense soils, 30 to 40 feet; clay, loam, and sandy clay soils, 60 feet; sandy loam soils, 100 feet; gravelly soils, 150 to 200 feet.

The underdrainage of orchards on clay land is almost essential in order to get good yields. In draining orchards, a line of tile is laid between adjoining rows, or between pairs of rows, at a depth of about 4 feet.

Grade.

A very slight grade will suffice for the flow of water in tile if properly laid. Tile drains will operate on a fall of ½ inch per 100 feet, but a fall of 6 inches or more per 100 feet is much more desirable. The less the fall the greater the precaution that must be taken in the construction work and the larger the tile that must be used.

Size of Tile.

The size of tile is determined largely by (1) the area drained, (2) the fall, (3) the texture of the soil, (4) the amount and intensity of the rainfall.

Area Drained. The size of the tile required increases with the area drained by that line; thus, drains spaced widely apart need to be larger than those placed near together. So far as the laterals of a regular system are concerned, however, the ordinary range of spacing does not affect the size of tile, since 4-inch tile will drain the land between such laterals, and the use of tile smaller than four inches is not advisable in any case, owing to its liability to become closed with silt.

Grade. The required size of tile decreases as the grade increases, since the quantity of water a tile can carry is the product of the cross-sectional area of the pipe and the velocity of the water, and the velocity is, of course, greater on a steep grade than on a flat one. Hence, if the grade be decreased the cross-sectional area must be increased in order to carry the same quantity of water, *i. e.*, a larger tile must be used.

Texture of Soil. In general, tile drains need to be larger in a soil of open texture than in a dense soil, since in the former the water passes

through the soil more rapidly, and the tile must be capable of carrying off this water. For ordinary crops, the size of the tile should be such that they will remove the surplus water from the surface of the ground within twenty-four hours.

AREAS DRAINED BY TILE MAINS.

(Based upon Kutter's formula, n=.015).

Size of Tile—	Fall Per 100 Feet			
Inches	1¼ inches or 0.1 foot	2⅜ inches or 0.2 foot	3⅝ inches or 0.3 foot	4¾ inches or 0.4 foot
	Acres Drained			
4	4	5	7	8
5	7	10	12	14
6	12	17	21	24
7	19	27	33	38
8	28	39	48	56
10	51	71	88	101
12	86	119	147	171
	6 inches or 0.5 foot	9 inches or 0.75 foot	12 inches or 1.0 foot	24 inches or 2.0 feet
	Acres Drained			
4	9	10	12	18
5	16	20	23	32
6	27	33	39	55
7	42	52	59	84
8	62	75	87	122
10	113	140	161	223
12	190	232	268	379

Rainfall. In regions of intense and large rainfall, taking into consideration, also, the climate and season of the year in which the heavy storms occur, the size of the tile should be larger, other influencing conditions being similar, than where the rainfall is small and does not come in heavy downpours. In regions where a great quantity of snow falls in the winter months and is carried off mainly in the spring, usually flooding the lowlands at plowing and planting time, this fact should be taken into account in determining the size of the tile. Where the annual rainfall is from 35 to 45 inches, and under standard conditions of climate, surface, and soil, it has been found that satisfactory drainage can be obtained if the mains are designed large enough to remove a depth of one-quarter inch of water from the area drained, in twenty-four hours. In some parts of this State, particularly in the eastern section, the annual rainfall amounts to from 45 to 60 inches, and there occur many heavy thunderstorms during the growing seasons. The

climate, however, offsets to a large extent the damaging effect of this large rainfall. There is no great accumulation of snow during the winter to run off in the spring, and evaporation and the exhalation of water by plants play quite a part in taking up the excess water.

It has been found satisfactory in North Carolina to design systems to remove a run-off of one-quarter inch in twenty-four hours. The above table gives the areas drained on this basis for the various sizes of tile laid on different grades. When outside water is admitted to the system, as through surface inlets, the size of the tile should be so increased as to carry a run-off of one inch in twenty-four hours. In using the foregoing table, therefore, the actual acreage supplying *outside* water should be multiplied by four.

No attempt should be made to make the capacity of the main equal to the combined capacity of the laterals. The size of main as determined from the above table will be the same regardless of the number of laterals entering it. As before stated, tile less than four inches in diameter are not recommended, owing to the danger of the smaller sizes becoming clogged with silt. The capacities of pipes laid on the same grade vary approximately as the squares of their diameters, hence a 4-inch tile has nearly twice the water-carrying capacity of a 3-inch tile. The small difference in the cost of the 3-inch and 4-inch tile will not offset the difference in their efficiencies.

Construction of Tile Drains.

Outlet Ditches.

The first requirement for the successful working of a tile drainage system is a good outlet. A free outlet should be obtained whenever possible, that is, the water from the tile should discharge above the water level in the outlet ditch or stream. On rolling or hilly land this condition almost always exists in the natural streams and ravines, but on flat land it is usually necessary to construct an outlet ditch. The obtaining of outlet drainage in the extensive flat areas of the State is usually a matter of organizing a drainage district and having the ditches constructed by dredges; it is, however, beyond the purpose of this Bulletin to discuss this phase of the subject. On individual farms it is sometimes necessary to improve natural streams or to construct outlet ditches to these large district ditches, in order to avoid the use of tile so large that it would be too costly to install them. Except on the most valuable land it is not economical in North Carolina to use tile larger than twelve inches in diameter. Where larger tile would be required it is best to construct an open ditch. General specifications for this kind of ditch may be summed up as follows: The bottom width should not be less than four feet, and the side slopes not steeper than one-half horizontal to one vertical. The bottom of the ditch should be at least one foot below the bottom of the outlet tile. The alignment should be as straight as practicable, all changes in line being made with easy curves, and the bottom should be given a smooth grade.

Laying Out the Drains.

A drainage engineer, in order to secure accuracy and conformity to the natural surface conditions, usually, first makes a topographic survey

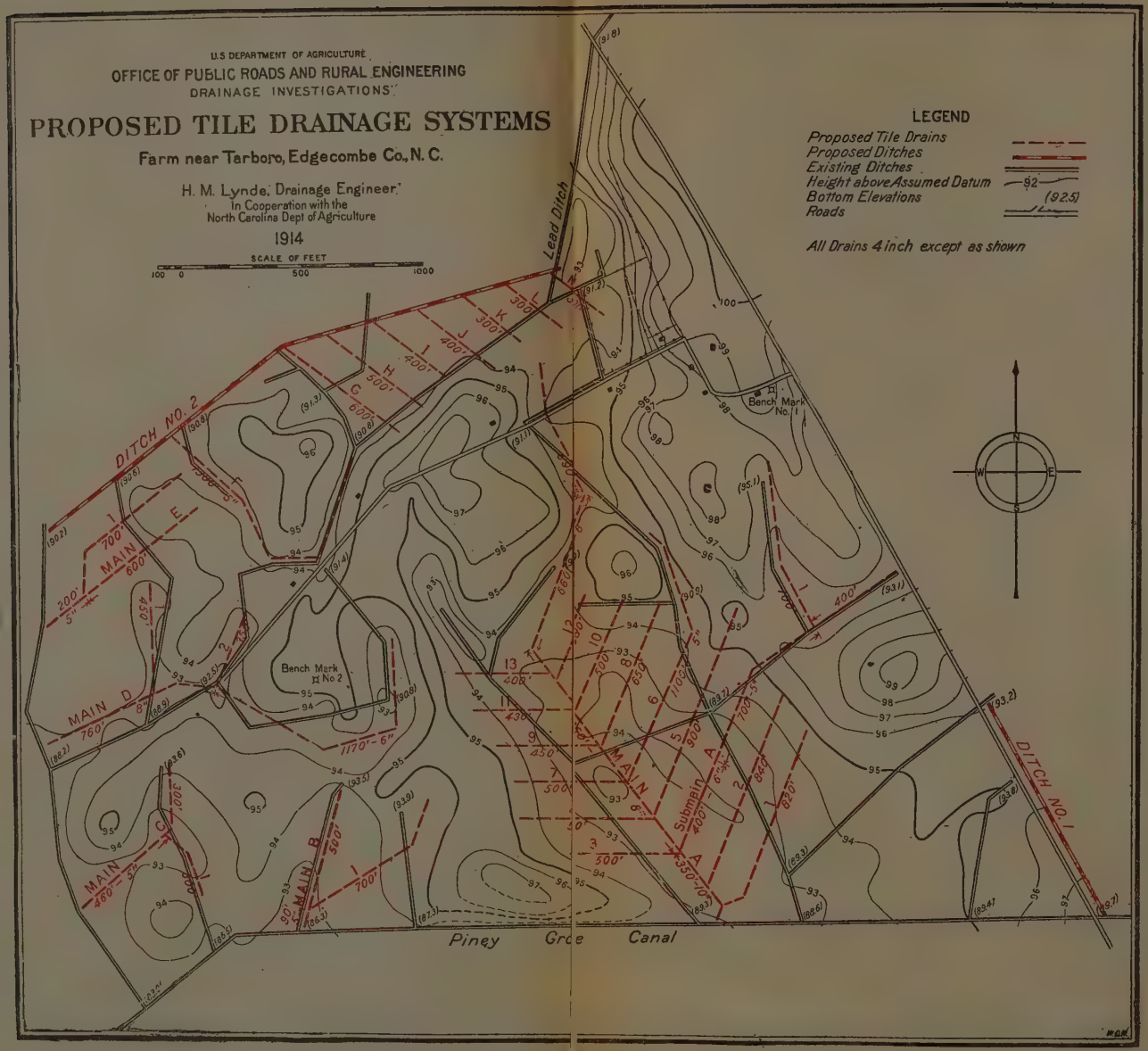

U.S DEPARTMENT OF AGRICULTURE
OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING
DRAINAGE INVESTIGATIONS
PROPOSED TILE DRAINAGE SYSTEMS
Farm near Tarboro, Edgecombe Co., N. C.
H. M. Lynde, Drainage Engineer.
In Cooperation with the
North Carolina Dept of Agriculture
1914
SCALE OF FEET
100 0 500 1000
LEGEND
Proposed Tile Drains
Proposed Ditches
Existing Ditches
Height above Assumed Datum 92
Bottom Elevations (92.5)
Roads
All Drains 4 inch except as shown
Lead Ditch
DITCH NO. 2
MAIN E
MAIN D
MAIN C
MAIN B
MAIN A
Submain A
DITCH NO. 1
Bench Mark No. 1
Bench Mark No. 2
Piney Grove Canal
N
S
E
W

Fig. 4.

of the area to be drained, by taking elevations at frequent intervals over the field. A map is then drawn, and the elevations are represented by contour lines, or lines joining points of equal elevations, to indicate the character of the surface. The entire drainage system is then laid out on this map, and the drains in the field are staked out from this record. Fig. 4 shows a typical drainage map of a tract of about 218 acres. Besides the contours, all other surface features are shown, such as open ditches and buildings, as well as the proposed system of drainage. This map is interesting, also, in that it illustrates how a farm now badly cut up into irregularly shaped fields by open ditches can all be put into one large field by replacing the open ditches by tile. On this map are illustrated the gridiron, herring-bone, and random systems.

On small areas, or where only random drainage in pronounced depressions is required, this preliminary work is not necessary, and the drains may be staked out at once in the field. In any case, however, a record should be kept of the courses and lengths of the different lines,

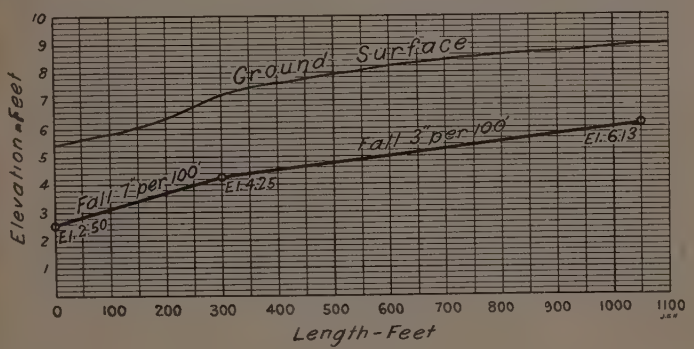


FIG. 5. Profile of Tile Drain.

and a map made, so that if at some future time it is necessary to inspect the drains or to make junctions they can easily be relocated. Any one who has much draining to do should procure a farm level; a satisfactory level and rod can be bought for about $15.

The tile ditches, as laid out in the field, are usually indicated by pairs of stakes, one a small square stake, or "grade hub," driven about flush with the ground. The elevation of the top of this stake is taken, and all measurements are made from it. The other is a guide stake—from two to three feet in length and about four inches wide—set about three inches in front of the grade hub and a little to one side, on which the station number and exact depth to dig below the top of the grade hub are given. After these pairs of stakes have been laid out along the line of the drain—usually fifty feet apart—and levels have been taken on top of each grade hub, a profile of the line is made, to scale, on profile paper. Such a profile is shown in Fig. 5. It indicates the ground surface and fall of the drain. The elevations of grade at the termini of the drain and at the point where the fall changes are also shown. The average depth at which the tile is to be laid, and the slope of the natural surface

along the line of the drain as indicated by the profile, usually determine the grade of the bottom of the ditch. A uniform grade should be obtained, if possible, but it is often advisable to break the grade in order to save excavation. On level land, the grade is determined by the minimum permissible in the particular type of soil and size of tile; on such land the tile will be deeper at the outlet than at the upper end. After the grade has been determined, the depth to dig at each 50-foot station is obtained by subtracting the computed elevation of the bottom of the ditch at each point from the elevation of the grade hub.

The grade of a lateral should be so adjusted that it will enter its main slightly above the grade line of the latter, the amount depending upon the size of the main tile. This difference in grades is known as "drop," and is usually one-half the diameter of the main tile.

Digging the Ditch.

The ditch is dug at a distance of about ten inches to one side of the line of stakes, and, for convenience in aligning the ditch, a cord should

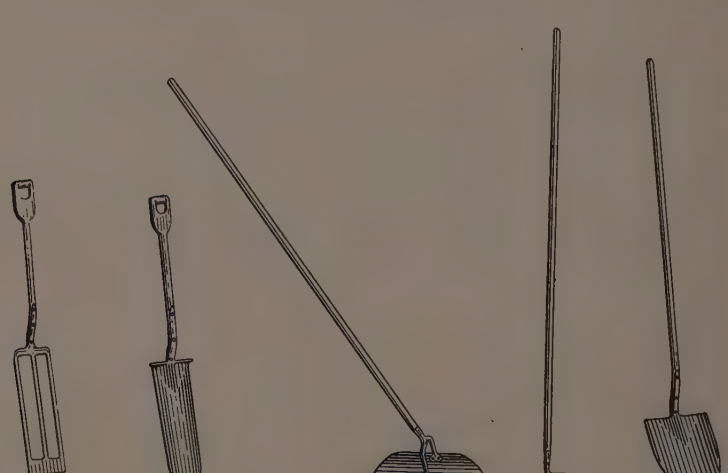


Fig. 6. Tools Used in Constructing Tile Drains.

be stretched on the ground between stakes. Bends in the line should be made by easy curves. The ditch should be made as narrow as practicable and with almost vertical sides, so that at the bottom it is slightly wider than the tile it is to receive. A width of twelve inches on top is enough for a ditch three feet deep, for 4-inch tile. It takes skill, combined with thought and practice, to dig a ditch as narrow as this, and do it rapidly and well, but when once the knack is acquired such a ditch is cheaper and much more satisfactory than is a wide ditch such as one often sees. The ditching should start at the outlet and proceed upgrade, the laying and "blinding" following closely. Working up-grade is

almost essential in soils containing water, in order that the water may not accumulate in the ditch. It is well to complete the main ditch before starting the laterals.

Ditching Tools. The special tools most commonly used by the tile ditcher are an ordinary long-handled shovel, tile spades, drain scoop, and tile hook. These are illustrated in Fig. 6.

The long-handled shovel is used in evening the top of the ground in a plowed field before starting to dig, and in removing the crumbs of dirt after each hand-dug course, or "lift," of the spade.

The tile spades are of two kinds, solid and open, the solid spade being the more common and practical type for most soils of this State. The open spade is used in digging muck soil and sticky clay soils where the soil is apt to stick to the back of the solid spade. The spades are from 16 to 22 inches long—18 to 20 inches being the most common lengths. Expert ditchers usually have two widths of spades, the narrower one to be used for the last lift.

The drain scoop, or drain cleaner, is an implement, semicylindrical in shape and fitted to a long handle, used to make the bottom of the ditch smooth and of a rounded shape, so that the tile can be laid evenly and with close joints. This tool can be either pushed or pulled, whichever is the most convenient. (See Plate IV.) It is made with either an adjustable or a nonadjustable handle, and for the different sizes of tile up to eight inches.

If the bottom of the ditch is smooth and uniform, the workman can lay the smaller sizes of tile without getting into the ditch, by using the tile hook. (See Plate V.)

Trenching Machines. Several types of trenching machine are on the market which are suitable for use on the farm and in sections where labor is scarce and there is a large amount of work to be done. It is frequently advisable for a number of persons to coöperate in purchasing such a machine. There are, however, but few individual farms in the State which are large enough to justify the purchase of a machine if used privately. A good trenching machine can be bought for about $1,500. Besides the trenching machines, there are various horse-drawn implements or plows which aid in digging hand ditches, by loosening the earth and partly removing it. Such machines cost from $20 up.

Grading the Bottom of the Ditch.

The exact grade of the bottom of the ditch can be most readily established by measuring from a line drawn taut over the middle, or at the side of the ditch, at a convenient height above the surface of the ground and at a constant distance from the proposed bottom of the ditch. To fix this line in its proper position, the method of using cross bars is probably as good as any. This method is illustrated in Plates II and III. Six feet is a convenient distance above the bottom of the ditch to stretch the line; at this height it will not interfere with the workman, since the grading line need not be placed in position until the ditch is about two-thirds dug. The method of obtaining the depth to dig at each 50-foot station is described under the heading "Laying out the Drains." The principle of the grading line is to secure a line parallel with the bottom of the proposed ditch and six feet above it. Therefore, at each

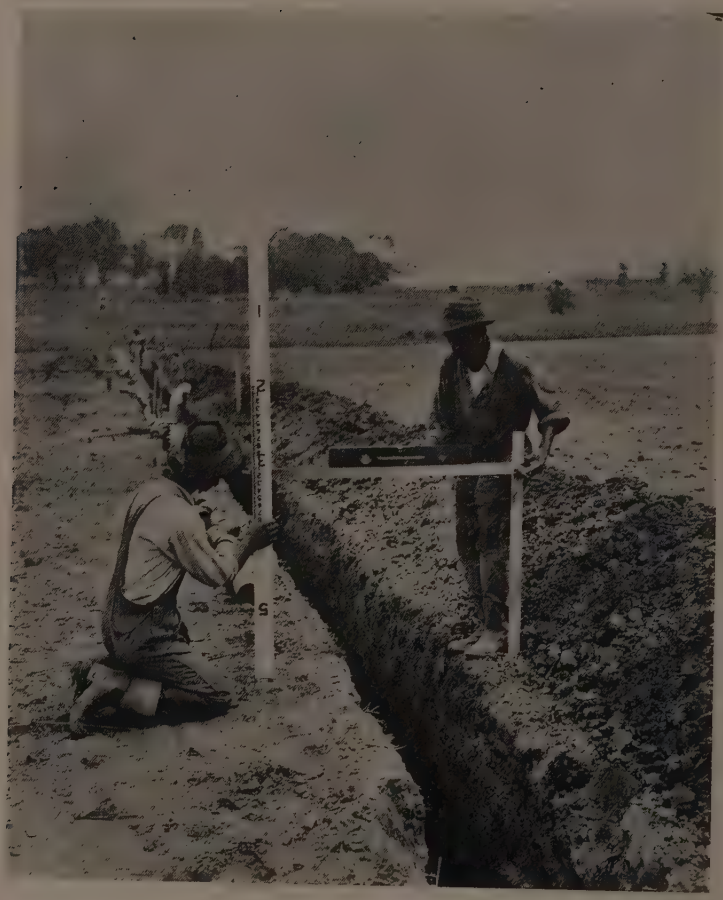


Plate II. Setting Cross-bar to Support Grading Line.

Plate IV. Finishing Grade With Tile Scoop.

PLATE V. Laying Tile With Tile Hook.

50-foot station drive firmly an upright stake on each side of the ditch, and nail or clamp a cross bar to them, with its top side at a distance above the grade hub, found by subtracting the depth to dig at this point from 6 feet. The cross bar is made horizontal by using an ordinary farm or carpenter's level. Plate II illustrates this operation.

Considerable mental work may be saved by using a measuring rod exactly six feet in length, accurately subdivided into feet, tenths, and hundredths, and numbered from one end. By simply inverting the rod and placing the 6-foot end on top of the grade hub (see Plate II) the cross bar can be placed in position by reading down from the top of the measuring rod the depth to dig at that point. The measuring rod may, of course, be graduated into feet, inches, and fractions of an inch, if desired. A convenient method of attaching the cross bar to the uprights is by the use of iron clamps, found in every hardware store, for fastening the corners of quilting frames. By their use, less time is required in moving and readjusting the line, and the uprights may be made of lighter material than if nails are used.

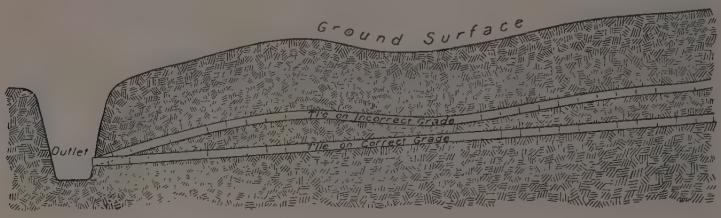


Fig. 7. Correct and Incorrect Grading.

Cross bars should be set up at three or more stations and a light, strong cord stretched taut across the tops of the bars between each station. No less than three cross bars should be in position constantly, so that if any error has been made in setting them it may be detected by sighting over them. By the frequent use of a measuring rod exactly six feet in length, the tile layer can accurately grade the bottom. Plate III shows the three cross bars in position, with a line stretched between them, and a workman testing the grade of the bottom. It is very important that the bottom of the ditch be made smooth and uniform, with no sags in the grade in which silt may collect. Fig. 7 shows, on an exaggerated scale, the comparative results that may be expected from grading by "eye" and by an instrument. Plate IV shows a workman finishing a grade by the use of the tile scoop.

Laying the Tile.

The tile may be laid either by hand or with a tile hook. If the bottom of the ditch is smooth and uniform, and the tile perfect in form, the workman can lay the smaller sizes—say up to eight inches—with the tile hook without getting into the ditch. Plate V shows a workman laying tile in this manner. The tile laying should begin at the outlet and proceed up-grade. The tiles should be made to join as closely as possible, as there will in any case be plenty of open space for the water to enter. If a tile is crooked and the ends not square, it should be turned

so that the tops join closely, any opening being left at the bottom. Openings of one-quarter inch or more should be covered with pieces of broken tile ("bats"), or, in some sandy soils, with cement mortar.

Junctions of laterals with their mains should be made by the use of junction tile, which should be put in place when the main is laid. "Y" junctions should be used in preference to "T" junctions, if possible. The former is a special piece made by manufacturers, in which the angle between the lateral and the main is between 45 and 60 degrees instead of 90 degrees, as is the case with the T. Thus, in the Y the currents from the two pipes unite with the least possible obstruction to flow. If Y's cannot be obtained, junctions can be made by fitting together straight tiles. Long curves may be made by using crooked tile, turning them about with the shortest side to the inner circumference of the curve. When making sharp curves with straight tile the openings should be covered with "bats," or for sandy soil, the ends of the tile can be clipped off, making one side shorter than the other.

At the end of each day's work the end of the tile line should be covered with a board, stone, or brick to prevent the entrance of mud and silt in case of a heavy rain. The upper ends of all laterals when completed should be closed by some durable material, as a stone or brick.

In soft ground it may be advisable to lay the tile on planks imbedded at grade. In wet, sandy soil the sand may be prevented from entering the joints by tamping clay firmly around them, or by wrapping them with cloth or tar paper. In quicksand it is often necessary to leave the trench open for several days to enable the surplus water to drain off before attempting to grade the bottom and lay the tile.

Backfilling.

As soon as the tile are laid they should be fixed in place by "blinding," which consists in covering the sides and top of the tile for a depth of six inches with moist, loose earth. The ditches should be filled in soon afterward by the least expensive method. This can be done either by shovels, plow, or team and scraper.

Protection of Outlets.

At the outlet of the tile system a head wall of stone, brick, or concrete should be built, so that the outlet pipe shall be held in place and the bank protected from caving. This should be at least one foot thick, and should extend from the ground surface to a depth of at least one foot below the bottom of the ditch in front of the head wall. A typical head wall is shown in Fig. 8.

The lower end of a main for a distance of ten feet should be of vitrified tile or second-grade sewer pipe. The end of the drain should be protected by wire screening to prevent the entrance of small animals, such as rabbits, which often build nests in them in dry seasons, thus obstructing the drain. Where surface inlets are used in a tile system a hanging screen is recommended, as shown in Fig. 8. A fixed screen in such cases is likely to catch débris washed into the inlet.

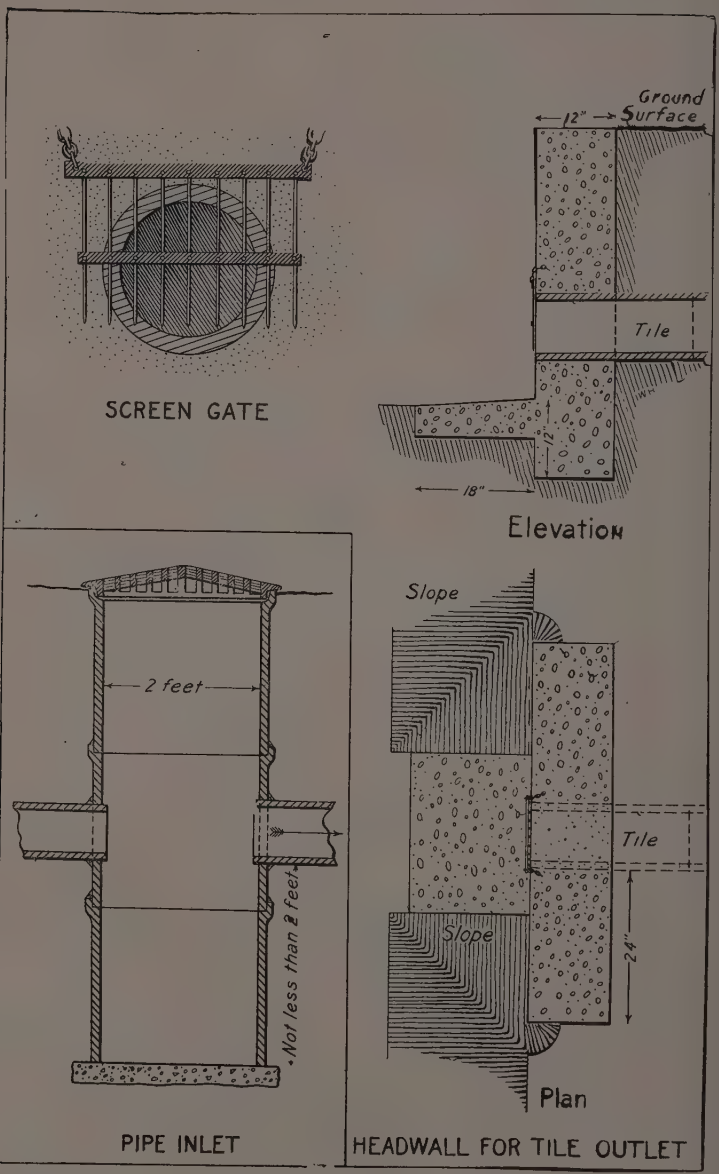


Fig. 8. Tile Outlet, Screen Gate, and Pipe Inlet.

Surface Inlets and Silt Wells.

Where large quantities of surface water are likely to collect, as in depressions or in road ditches which have no outlet, it is advisable to install surface inlets. A surface inlet is a well extending from the ground surface to a point 18 inches to 24 inches below the bottom of the tile, and lined with brick, concrete, or sewer pipe. A sewer-pipe inlet, with junction connections, is shown in Fig. 8. The top of the surface inlet should be fitted with an iron grating and covered with a pile of broken brick or small stones to prevent the entrace of trash. From time to time the brick or stone should be rearranged and the silt removed from the bottom of the well.

A silt well is similar to a surface inlet, except that it is not always arranged to admit surface water. Its principal function is to catch any silt moved down the tile by the water, and it is generally located at a point where the grade suddenly changes from very steep to very flat, thus causing the silt to settle in the bottom of the well, instead of possibly clogging the tile below. The silt well and surface inlet are often combined in the same structure.

OBSTRUCTIONS IN DRAINS.

Where tile are properly laid on a solid bottom and the trench filled immediately afterward, and where there is a good outlet, there should be no liability of the tile becoming clogged with silt. Mistakes are often made in replacing old open ditches by tile, by laying the tile in the ditch. These ditches are often crooked, have poor grades, and are filled with several inches of soft sediment; and in attempting to reach solid foundation for the tile it is found that a poor outlet results, the latter being sometimes submerged. On the other hand, if a good outlet is obtained some of the tile are likely to be laid on soft material and they settle and become clogged. In either case poor results are obtained and in most cases it is better to dig an entirely new ditch for the tile.

In systems where silt wells or surface inlets are used they should be inspected frequently and cleaned out when necessary.

Attention is called to the necessity of protecting the outlet. Farm stock, in search of drinking water, often trample the outlet tile if they are not properly protected by a headwall. In dry seasons, small animals will often find their way up into the tile and build nests, thus obstructing it, unless the outlet tile is protected by a screen.

It is generally conceded that the roots of cultivated plants will not enter a tile that is dry for several weeks in the summer. The reason is that the plants are in search of moisture and in such cases there is more to be found in the soil than in the tile. It is only when the drains receive water from a spring that runs throughout the year, and in times of extreme drought when there is a deficiency of moisture in the soil, that there is danger of the roots of certain plants entering the tile. There is generally more danger from the roots of water-loving trees like the poplar, willow, etc., than from the roots of cultivated plants; and it is not wise to install, too close to these trees, tile which conducts water from a spring.

Vertical Drainage.

This type of drainage has recently attracted some attention. The action of vertical drains depends upon the principle that in soils underlain by some porous bed of sand or gravel, the water can in some cases be conducted away by sinking a well in such a position that it will receive the drainage of the pond or wet tract. Whether or not this is possible depends entirely on local conditions at the point to be drained, the method being by no means generally applicable.

The efficiency of a drainage well depends principally upon the depth of the permanent ground water level, and upon the porosity or water-bearing capacity of the materials into which the drainage water is discharged. In order that the well shall be effective, it is necessary, first, that the general level of the ground water be permanently lower than the depression to be drained, and second, that the material of the conducting stratum be sufficiently porous and extensive to take up all of the water as rapidly as it is brought to it by the well. If these conditions do not exist the water will rise in the well and drainage will come to a standstill.

Areas on which it would seem that drainage wells should be effective are depressions where it is known that the elevation is considerably higher than that of a nearby stream and where the ground water level is low; and in "pot holes" where the water which accumulates is independent of the ground water, being due to a hardpan which holds the surface water. If the ground water is found to be but a few feet below the surface, the well probably will not be effective; but if it is ten or twenty feet below the surface, it may be advisable to try this means of drainage. The well is usually lined with 8-inch tile and the upper end of the column protected, either by a patented drain head or by covering it with an inverted flower pot or flat stone placed about three feet below the surface and covered with gravel. Great care should be used to prevent silt entering the pipe.

Cost of Tile Drainage.

The cost of tile drainage varies greatly, depending on the nature of the soil, the presence of stone and roots; the spacing, depth, and size of tile; the season of installation; the methods of construction; and local labor conditions. The cost of 4-inch tile varies from $16 to $20, 5-inch from $20 to $30, and 6-inch from $25 to $40 per thousand feet in car lots f.o.b. factory, the variation in cost being due to the quality of the tile and to the amount of business done. Some of the factories that quote low prices are located out of the State, so that with freight added their prices are not much different from those of the local product. With freight added, the prices for tile delivered at the nearest railroad station will ordinarily not exceed $25 per thousand feet for the 4-inch, $35 for the 5-inch, and $45 for the 6-inch tile. For sizes larger than 6-inch the manufacturers in this section usually sell second grade sewer pipe, which with freight added cost for the 8-inch size $.07 to $.08 per foot, 10-inch $.11½ to $.13 per foot, and for 12-inch $.15 to $.17 per foot. For 6-inch tile or under, the cost of digging the ditch, laying the tile, and blinding and refilling, ought not to exceed a maximum of $.09 per linear yard for a ditch three feet deep.

At a cost of $25 per thousand feet for 4-inch tile, and $.09 per linear yard for digging, laying, and refilling; and assuming an acre of land to be drained with 4-inch tile, the cost will range from about $16 for tile spaced 150 feet apart to about $40 for tile spaced 60 feet apart. To this must be added the cost of the larger mains, of hauling of tile from railroad station to the farm, and of accessories like silt wells and headwalls. Likewise should be added the cost of engineering which is variable. On land not requiring uniform drainage the cost for drainage may be as low as $8 per acre.

WILL TILE DRAINAGE PAY?

It is evident that the tile drainage of farm lands is not an inexpensive operation. The exact knowledge of this cost, however, has little significance unless at the same time a fair idea of the profit to be expected from drainage can be had. The extent to which tile drainage has been practiced in North Carolina is not such as to bring before its people in general the far-reaching importance of this form of improvement. Considerable tile has been laid in the draining of ponds, swales, and springs, but not very many uniform systems have been constructed. In Iowa, Illinois, and other States in the Middle West, tile drainage is considered the most important requirement for successful agriculture. There is no reason for doubting that the installation of tile in the South pays returns as large as is the case in the Middle West, where the soil is no better and the climate not as favorable.

There is an impression that our southern lands are too low in value to justify this seemingly expensive work of tile drainage. It is probably true that at least two-thirds of the area of the State may be termed "waste" land. What does this mean in the Coastal Plain Region? It means that much of the "waste" land is *wet* land. Most of the high land has been settled and cleared. As the population becomes greater and the country more densely settled there will be an increased demand for land, and as the price increases it will become more and more profitable to drain our wet farms. With the high prices that all farm products command today and the numerous markets available, it seems that it would pay to underdrain all land where there is the slightest chance for failure or partial failure of crops due to its present undrained condition. This would apply especially to truck crops. By underdrainage our so-called "cheap" lands would become the most valuable agricultural lands in North Carolina. One of the reasons why tile drainage is not practiced more is that the results of underdrainage are not generally understood. There is also an impression that the critical operations of putting in a tile system are more difficult than they really are and landowners, fearing a mistake, decline to undertake the work.

Tile drains, properly installed, are a permanent investment and very little maintenance is required. The increase of crops in from six to ten years will usually pay for the cost of drainage, after which this increase is an annual profit for an indefinite time. Underdrainage is becoming more thoroughly understood in North Carolina, and from present indications the most extensive work of this character that will be done in the United States during the next ten years will be carried on in this and other Southern States.

Dr. W. I. Chamberlain, in writing on the subject of tile drainage, answers the question "When can we afford to drain?" in this manner: "We cannot afford not to drain if we have land that we need for tillage and rotation and which is naturally unfit for it, but which can be fitted for it by tile drainage. Shall we wait until we are out of debt and have money to tile it, or shall we tile it in order to get out of debt? The latter as a rule."

JANUARY, 1916 BULLETIN 235

NORTH CAROLINA
AGRICULTURAL EXPERIMENT STATION
CONDUCTED JOINTLY BY THE
STATE DEPARTMENT OF AGRICULTURE
AND THE
COLLEGE OF AGRICULTURE AND MECHANIC ARTS
RALEIGH AND WEST RALEIGH

I

Some Further Studies of Chick Mortality

II

When to Feed the Baby Chick

Bulletins of the Station Will be Sent Free to Citizens of the State on Request

THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE

AND THE

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

BOARD OF AGRICULTURE

*W. A. GRAHAM, *Chairman*, Raleigh

F. P. LATHAM.....Belhaven
C. W. MITCHELL.....Aulander
*R. L. WOODARD.....Pamlico
*CLARENCE POE.....Raleigh
R. W. SCOTT.....Haw River
*A. T. MCCALLUM.....Red Springs
*C. C. WRIGHT.....Hunting Creek
WILLIAM BLEDSOE.....Gale
W. J. SHUFORD.....Hickory
A. CANNON.....Horse Shoe

BOARD OF TRUSTEES OF THE COLLEGE

GOVERNOR LOCKE CRAIG, *Chairman*.

M. B. STICKLEY.....Concord
T. T. BALLINGER.....Tryon
W. H. WILLIAMSON.....Raleigh
O. L. CLARK.....Clarkton
EVERETT THOMPSON.....Elizabeth City
R. H. RICKS.....Rocky Mount
O. MAX GARDNER.....Shelby
M. L. REED.....Biltmore
*T. T. THORNE.....Rocky Mount
*C. W. GOLD.....Greensboro
T. E. VANN.....Como
P. S. BOYD.....Mooresville
W. E. DANIEL.....Weldon
*W. H. RAGAN.....High Point
W. B. COOPER.....Wilmington
J. P. MCRAE.....Laurinburg

*D. H. HILL (President College), West Raleigh.

STATION STAFF

B. W. KILGORE.....Director
C. B. WILLIAMS.....Vice-Director
R. W. COLLETT.....Asst. Director, Branch Stations
F. H. JETER.....Agricultural Editor
MISS MARY S. BIRDSONG.....Sec'y to Director
C. B. WILLIAMS.....Chief in Agronomy
J. K. PLUMMER.....Soil Chemist
W. F. PATE.....Agronomist—Soils
E. C. BLAIR.....Assistant Agronomist—Soils
H. D. LAMBERT.....Assistant Agronomist—Soils
R. Y. WINTERS.....Plant Breeding
[1]BUXTON WHITE.....Assistant in Plant Breeding
[1]V. R. HERMAN.....Assistant in Plant Breeding
[2]W. E. HEARN.....State Soil Agent, Soil Survey
[2]R. B. HARDISON.....Assistant in Soil Survey
S. O. PERKINS.....Assistant in Soil Survey
L. L. BRINKLEY.....Assistant in Soil Survey
F. N. MCDOWELL.....Assistant in Soil Survey
[2]E. S. VANETTA.....Assistant in Soil Survey
A. R. RUSSELL.....Assistant in Field Experiments
W. A. WITHERS.....Chemist
F. E. CARRUTH.....Assistant Chemist
H. L. COX.....Assistant Chemist
J. M. PICKEL.....Feed Chemist
W. G. HAYWOOD.....Fertilizer Chemist
J. Q. JACKSON.....Assistant Chemist
E. S. DEWAR.....Assistant Chemist
E. B. HART.....Assistant Chemist
F. C. WIGGINS.....Assistant Chemist
FRANKLIN SHERMAN, JR...Chief in Entomology
Z. P. METCALF.....Entomologist
S. C. CLAPP.....Assistant Entomologist
R. W. LEIBY.....Assistant Entomologist
W. N. HUTT.....Chief in Horticulture
J. P. PILLSBURY.....Horticulturist
L. R. DETJEN.....Assistant Horticulturist
R. G. HILL.....Assistant Horticulturist
C. D. MATTHEWS.....Assistant Horticulturist
B. SZYMONIAK, Demonstrator in Fruit and Truck Crops
DAN T. GRAY.....Chief in Animal Industry
R. S. CURTIS.....Associate in Animal Industry
W. H. EATON.....Dairy Experimenter
B. F. KAUPP, Poultry Investigator and Pathologist
[3]A. J. REED.....Dairy Farming
[3]J. D. MCVEAN.....Pig Club Agent
[3]A. G. OLIVER.....Poultry Club Agent
STANLEY COMBS.....Assistant in Dairy Farming
[3]J. A. AREY.....Assistant in Dairy Farming
[3]F. R. FARNHAM.....Assistant in Dairy Farming
[3]J. L. GRAYBILL.....Assistant in Dairy Farming
[3]F. T. PEDEN.....Assistant in Beef Cattle
[3]A. L. JERDAN.....Assistant in Beef Cattle
[3]L. I. CASE.....Assistant in Beef Cattle
EARL HOSTETLER, Assistant in Beef Cattle and Swine
DAN M. MCCARTY, Assistant in Animal Nutrition
F. A. WOLF.....Plant Pathologist
R. O. CROMWELL.....Assistant, Plant Diseases
[4]H. M. LYNDE.....Senior Drainage Engineer
F. R. BAKER.....Assistant Drainage Engineer
[1]C. R. HUDSON.....Farm Demonstration
[1]T. E. BROWNE.....Asst. in Charge Boys' Clubs
[1]MRS. C. MCKIMMON Assistant in Charge Girls' Clubs
[1]A. K. ROBERTSON.....Assistant in Boys' Clubs
[1]MISS MINNIE L. JAMISON, Assistant in Home Economics
G. A. ROBERTS.....Veterinarian
W. R. CAMP.....Marketing
[1]J. M. JOHNSON.....Farm Management
[1]E. H. MATTHEWSON.....Tobacco Expert
A. F. BOWEN.....Bursar

F. T. MEACHAM.....Assistant Director Iredell Branch Station, Statesville
J. H. JEFFERIES.....Assistant Director Pender Branch Station, Willard
C. E. CLARK.....Assistant Director Edgecombe Branch Station, Rocky Mount
[1]E. G. MOSS.....Assistant Director Granville Branch Station, Oxford
S. F. DAVIDSON.....Assistant Director Buncombe and Transylvania Stations, Swannanoa

The members marked with * are members of the Joint Committee for Agricultural Work, and the Station is under their direction.

[1]In cooperation with the U. S. Department of Agriculture, Bureau of Plant Industry.
[2]In cooperation with the U. S. Department of Agriculture, Bureau of Soils.
[3]In cooperation with the U. S. Department of Agriculture, Bureau of Animal Industry.
[4]In cooperation with the U. S. Department of Agriculture, Office of Public Roads and Rural Engineering.

PART I

SOME FURTHER STUDIES OF CHICK MORTALITY

By B. F. Kaupp, Poultry Investigator and Pathologist.

HISTORICAL.

The fowl is the most delicate of all domesticated animals. It is more difficult to raise, and the mortality of the young is very high. Much study has been devoted by many laboratories along the lines of determining the causes and prophylactic measures against chick mortality.

Professor Dryden[1] states, when reporting his experiments relative to the causes of chick mortality, that 16.6 per cent of the chicks were dead in the shell when incubated artificially, while the chicks dead in the shell when incubated under the hen were only 2.8 per cent. The necessity of having artificial conditions exactly the same or fully as favorable as in nature is quite apparent, because infant life has far less resistance and endurance than adult life.

Pernot,[2] in 1908, makes a report of an extensive investigation conducted to determine some of the causes of chick mortality. Chicks dead in the shell and those that had just died were examined. It is stated that much coagulated blood was found about the unabsorbed abdominal yolk. Inoculations were made from the yolk sac, and about fifteen different kinds of bacteria were isolated. However, only one of these proved pathogenic. This one was a short bacillus with rounded ends, occurring singly and in pairs. From his investigations, Pernot came to the conclusion that the birds died in the shell from toxemia. The chicks that hatched and were invaded with these germs are said to be affected by a whitish diarrhea, and from them the organism can be isolated.

Rettger and Stoneburn,[3] in 1909, reporting investigations made by them in Pennsylvania, New York, New Jersey, and the Province of Ontario show that on all farms visited, where incubators were used, the chicks were dying of white diarrhea. The loss varied from 10 to 90 per cent. They state that in the course of their investigational work an organism was isolated from the liver and spleen and other internal organs. Inoculation experiments with pure cultures of this organism resulted in the reproduction of the disease and a recovery of the organism from the internal organs. These observations showed that the chicks died between the first and fourth weeks, and that the older chicks were immune. This organism was later called the Bacterium Pullorum. The condition it produced was called Bacillary White Diarrhea. The bacterium is a long, slender rod with slightly rounded ends. It is nonmotile and stains readily with the ordinary analine dyes. In their summary, these investigators state that the mother hen is the original source of the disease. A certain percentage of the chicks raised on infected farms have the disease when hatched. It is then transmitted through the food supply. The mortality depends upon the number and the viru-

lence of the organisms. While a large percentage of infected chicks die under four weeks of age, some may survive the infection, but these are likely to be weak and stunted, and seem particularly susceptible to other disorders.

Rettger and Kirkpatrick,[4] in 1912, gave the following summary as to their conclusions from studies made of bacillary white diarrhea:

"The period of the greatest danger from bacillary white diarrhea lies within the first forty-eight hours. Chicks may acquire the disease, however, up to the time they are four days old.

"Hens may become bacillus carriers after they have reached maturity. The ovaries may become infected by contact of the hens with infected hens, or by artificial infection of the litter. The infection is, in all probability, acquired through the mouth.

"The feeding of sour milk to chicks appears to be a good means of preventing, or at least, holding in check, epidemics of bacillary white diarrhea. Hence, whenever it is impossible or impracticable at once to introduce new stock, sour milk may be an important agent in lessening the dangers of great loss from the disease. The sour milk should be fed to the chicks as early as possible and should be kept before them constantly thereafter. Sour milk has an important stimulating effect on the growth and vitality of chicks, and for this reason alone is a most valuable food.

"For the complete elimination of white diarrhea from a poultry farm it is necessary to reject for breeding purposes stock which harbors white diarrhea infection, and to obtain eggs or live stock from sources where white diarrhea infection has not been known to exist.

"It should be considered both a moral and legal offense for persons to sell or exchange eggs, chicks or mature stock which come from flocks that they know to be infected with the germ of bacillary white diarrhea. Every precaution should be taken to protect mature stock against infection by the white diarrhea bacillus. It is, therefore, important that mature hens, as well as growing stock, be kept in good, clean houses and large yards; that they receive wholesome food and the best of care. Finally that they be not allowed to come in contact with infected chicks or mature stock."

The [5]writer,[6] during the years 1909, 1910, 1911, made studies in Colorado as to the cause of diarrhea among baby chicks. A type of diarrhea was found in which the coccidium tenellum caused ulceration and destruction of the mucous membrane of the intestines, especially the small intestines and ceca. In prepared sections the coccidium was studied in all stages of its development. In some localities another type existed in which there was an absence of the coccidium, and from which birds the bacillus described by Rettger was found. The symptoms as observed were droopy wings, ruffled feathers, sleepiness, a tendency to huddle together, and little or no appetite. The abdominal yolk was not properly absorbed, and a whitish or a whitish-brown, frothy discharge from the bowels adheres more or less to the vent fluff; the eyes were closed part of the time and there was apparently no interest in life. Many of the chicks presented a stilted appearance, with abdomen prominent behind, and peeped much of the time. The symptoms of the coccidian type were similar to those of the bacillary type.

Pearl and Surface[7] state that conditions of housing have a marked and definite influence on the mean average fertility and hatching quality of eggs. In experiments, it was found that both the fertility and the hatching quality of eggs were very much better when breeding was done in a curtain-front house, which furnished an abundance of fresh air, than

when it was done in what was formerly considered to be a highly desirable type of heated house, without curtain-front, but with a supposedly adequate system of indirect ventilation.

The individuality of the female bird is a very important factor in the determination of the fertility of the eggs. The eggs of the heavy winter layers are not more likely on an average to be more infertile than are those of the light winter layers, other conditions being the same. In general the higher the winter egg production of a particular bird the lower will be the percentage of fertile eggs hatched.

A bird whose eggs are of superior hatching quality in her pullet year will, on the average, show the same characteristics in her second year.

Any factor which tends to reduce or impair the general constitutional vigor of breeding birds in general tends also to reduce the hatching quality of the eggs produced by these birds. Improper feeding as well as improper housing are also factors.

BUTTERMILK IN THE CONTROL OF CHICK MORTALITY.

Investigations have shown that the bird behaves differently in many respects from some of the higher animals, and that many things cannot be taken for granted from analogy but must be worked out. Thus, Metchnikoff[8] has shown that the normal fowl exhibits almost complete immunity to tetanus toxin, but contains no antitoxin in its blood. Again it is known that certain white blood-cells in other animals have the power to devour or take up and destroy harmful bacteria. This process is called phagocytosis, and the white cells, phagocytes. Certain chemical substances in the fluids of the body act upon the bacteria, rendering them easily taken up and destroyed by the white blood-cells.

Kite and Wherry[9] have recently shown that these cells take up bacteria and foreign bodies from the tissues because of the fact that they are endowed with amœboid movement. The chemical substance modifies the organisms so that the surfaces are sticky and the devouring cells, rolling along and throwing out their prolongations, take up the objects, and by the fluids of their bodies overcome and dissolve them.

Heinemann,[10] who has devoted much time to the study of milk bacteria from a pathological standpoint, has the following to say in his conclusions from the careful study of the germicidal effect of lactic acid in milk: "Some acid-tolerant cells of bacillus coli may survive the presence of 0.6 per cent lactic acid in milk."

In Heinemann's experiments the bacteria of B. dysenteriæ, B. typhosus, B. diphtheriæ, B. paratyphosis, and Spirillum choleræ were destroyed by the presence of 0.45 per cent lactic acid. It is possible that strains of these bacteria exist which are able to resist a greater amount of lactic acid.

Acid tolerant strains of B. coli, B. dysenteriæ, B. typhosis, and B. paratyphosis may multiply in the presence of quantities of lactic acid which are destructive to the majority of cells. The smaller the initial amount of lactic acid the more likely is the growth of acid tolerant strains. Consequently, the slower milk sours the greater is the danger of pathogenic germs surviving.

The growth of the test bacteria is influenced to a marked degree by the amount of acid present. Up to a fairly definite amount of acid there is an increase in the bacteria, followed by a decrease which becomes more pronounced as the amount of acid increases. The amount of acid may increase after the number of bacteria has begun to decrease, owing to the liberation of enzymes.

Acids other than lactic acid are frequently present in buttermilk. It should be looked upon with suspicion, especially if heavily polluted, unless it has been prepared from pasteurized milk. However, the chances of buttermilk becoming a carrier of infection are less than the raw sweet milk.

The presence of saprophytic bacteria in buttermilk may have some influence on pathogenic bacteria. Whether this influence is favorable or otherwise is difficult to determine by present bacteriological methods.

Metchnikoff[11] and his school have claimed that some of the symptoms accompanying old age and arteriosclerosis are due to the absorption from the intestinal tract of chemical substances due to the activity of germs. He claims that buttermilk, and especially the Bulgarian buttermilk, produces conditions unfavorable to the life and growth of harmful bacteria, and hence advocates the consumption of buttermilk as a healthful drink.

EXPERIMENTS.

Nature of Tests Made.

It was decided to run two sets of tests on baby chicks during the season of 1915. The birds were divided into four sections as follows: section 1 received sour (clabber) milk; section 2, Bulgarian buttermilk; section 3, artificial buttermilk made from the B. acidi lactici; and section 4, the control lot, received no milk.

Preparation of the Milk.

The milk was obtained from a dairy which produced milk under sanitary regulations, and was sent to the laboratory as soon as drawn and cooled.

The milk for lot No. 1 was poured into sterilized bottles and allowed to sour at room temperature. It was used the following day both for the chicks to drink and as a material with which to mix the feed.

The milk for lot No. 2 was poured into sterilized bottles and inoculated with a pure culture of a high acid-producing strain of the B. bulgaricus obtained from the American Public Health laboratories of New York and from H. K. Mulford Co., of Philadelphia. The inoculated milk was allowed to stand at room temperature and was used on the following day.

The milk for lot No. 3 was poured into sterilized bottles and inoculated with a pure culture of the B. acidi lactici, of high acid-producing qualities, the culture being originally obtained from Parke-Davis Co., of Detroit.

HOUSING AND RUNS.

The baby chicks were allowed to remain in the nursery trays of the incubator until they were 72 hours old and were then placed in woolen lined boxes and removed to the brooder house. The brooder house is a structure sixteen feet wide and sixty feet long, heated by hot water. The brooder room was kept at a temperature approximately 70° F. The chicks were brooded in International hovers heated by kerosene oil. The runs were provided with concrete floor inside the building with an additional run eight by twelve feet outside the building. The inside floor was kept covered with straw, which was changed as often as it became unsanitary. The water fountains and feeding equipment were of glass and were washed and disinfected daily. The lamps in the hovers were trimmed and refilled once a day. The hovers were kept at a temperature of between 100° and 110° F. during the first week and reduced about ten degrees a week thereafter.

SOURCE OF THE BABY CHICKS.

The chicks were a mixture of different breeds from the foundation stock, thus giving a test of different purebred varieties. The eggs were collected once daily, placed in storage trays in the basement, and turned daily. The eggs from which the chicks were hatched were set as fresh as possible, an effort being made not to use those over two weeks old.

The eggs were incubated in a Newton Giant incubator in which the temperature was kept at 102 to 102½° F. the first week, 102½ to 103° F. the second week, and 103 to 103½° F. during the third week. The eggs in the trays were turned once daily until the eighteenth day, when the apron was removed and the chamber kept closed until hatching was over.

The baby chicks were held three days in the nursery tray, a cheesecloth apron hanging before the glass door to darken the chamber. On the third day the chicks were stronger than on the first day.

The chicks were of the following breeds: S. C. Rhode Island Red, S. C. White Leghorn, Barred Plymouth Rock, Buff Orpington, Columbian Wyandotte, Partridge Plymouth Rock, Houdan, Dark Cornish, Silver Penciled Wyandotte, Silver Spangled Hamburg, White Faced Black Spanish, White Plymouth Rock, Silver Compine, and Buff Plymouth Rock.

THE FEED.

The best grade of feeds were used, and the following rations were fed:

RATION No. 1.

Rolled Oats	8 parts
Bread Crumbs	8 parts
Sifted Beef Scrap	2 parts
Bone Meal	1 part

Nutritive ratio, 1:3.3

RATION No. 2.

Cracked Wheat	3 parts
Cracked Corn (fine)	2 parts
Pin Head Oat Meal	1 part

Nutritive ratio, 1:7.7.

Ration No. 3.

Ground Wheat	6 parts
Corn Meal	3 parts
Beef Scrap	3 parts
Bone Meal	1 part

Nutritive ratio: 1:2.4.

Ration No. 4.

Whole Wheat	3 parts
Cracked Corn	2 parts
Hulled Oats	1 part

Nutritive ratio, 1:7.6.

For the first five days the baby chicks were fed Ration No. 1 five times a day from five to fifteen days, Ration No. 1 and No. 2; after fifteen days a day; from five to fifteen days, Ration No. 1 and No. 2; after fifteen days times a day in addition to Nos. 1 and 2, and at the end of fifteen days it was fed only twice a day. After the chicks were thirty days old they were given moist mash once a day. The dry mash was kept in hoppers before them at all times. After thirty days Rations Nos. 3 and 4 were given in hoppers. Nos. 1 and 2 were discontinued. The flocks were placed on range at the age of eight weeks. After the fifth day the chicks were allowed to run on the fresh spaded earth.

Several series of tests were made, but one series will serve to illustrate the results.

The Sour Milk Lot.

As soon as the chicks in the sour milk lot were taken from the incubator they were given at all times all the sour milk they would drink. A mash (Ration No. 1), wet with sour milk, was also given five times a day. Sprouted oats and hard boiled eggs, which had been chopped into small pieces, were mixed with this mash. Ration No. 2 was given in addition to Ration No. 1, from the fifth to the fifteenth day. After fifteen days Ration No. 3 was fed mixed with sour milk, twice daily. After the chicks were four weeks old they were given Ration No. 4 and Ration No. 3.

The following table shows the rate of mortality:

Table No. 1.

Date	No. Chicks	Per Cent Loss	Per Cent Raised
3-11-15	87	....	....
3-12-15	85	....	....
3-13-15	83	....	....
3-14-15	80	....	....
3-15-15	73	....	....
5- 6-15	73	16	84

Diarrhea attacked the flock during the first week and resulted in some loss, but the individuals soon regained their usual condition and showed no permanent ill effects.

From an analysis of the above table it will be seen that of this lot of 87 baby chicks, 16 per cent died during the first four weeks, leaving 84 per cent that escaped the ravages of diarrhea.

THE BULGARIAN BUTTERMILK LOT.

This lot was fed the same as Lot No 1 except Bulgarian buttermilk was used in the place of plain sour milk.

The following table shows the rate of mortality:

TABLE NO. 2.

Date	No. Chicks	Per Cent Loss	Per Cent Raised
3-11-15	70	....	....
3-12-15	69	....	....
3-14-15	67	....	....
3-15-15	65	....	....
3-16-15	64	....	....
3-17-15	63	....	....
3-26-15	63	....	....
5-11-15	63	10	90

Diarrhea attacked this flock during the first week, but had entirely disappeared by the end of the fourteenth day. The attack was light and the survivors appeared not to be stunted.

From an analysis of the above table it will be seen that 10 per cent died and 90 per cent lived.

THE B. ACIDI LACTICI BUTTERMILK LOT.

This lot was fed the same as Lot. No. 1, except that artificial buttermilk, made from the B. acidi lactici, was used.

The following table shows the rate of mortality:

TABLE NO. 3.

Date	No. Chicks	Per Cent Loss	Per Cent Raised
3-11-15	74	....	....
3-12-15	72	....	....
3-14-15	70	....	....
3-15-15	67	....	....
3-16-15	66	....	....
3-17-15	65	....	....
5-11-15	65	12	88

Diarrhea attacked this lot during the first week, but the attacks were light and entirely disappeared by the end of the second week. No ill effects appeared to follow.

From an analysis of the above table it will be seen that of the 74 chicks 12 per cent died and 88 per cent lived to the eighth week.

THE CONTROL LOT.

This lot was fed the same as Lot No. 1, except that milk was not used. Water was used to moisten the mash and was also kept constantly before the chicks for drinking purposes.

The following table shows the rate of mortality:

Table No. 4.

Date	No. Chicks	Per Cent Loss	Per Cent Raised
3-11-15	41	....	....
3-18-15	36	....	....
3-24-15	35	....	....
3-31-15	33	....	....
4- 7-15	32	....	....
4-14-15	31	24	76
5- 5-15	26	36	64

This flock, like the three preceding lots, was attacked by diarrhea which claimed a toll of 24 per cent during the first four weeks and left the remainder of the flock in such a wrecked condition, constitutionally, that by the end of eight weeks 36 per cent had died.

All of these lots of chickens were raised on ground that was infected by the Bacterium pullorum. It was felt that, from a practical standpoint, it would be better to have the tests maintained under farm or commercial plant conditions than to inoculate experimentally. Natural infection is what the farmer has to contend with.

That the narrow ration or excessive protein content of the feed did not produce these bowel derangements was later proven in five lots which were hatched in the incubator, brooded in new brooders, raised in a dense shade furnished by mulberry trees, and on ground that was known not to be infected. These lots were fed the same ration so far as grain and mash is concerned, but no buttermilk was used in the wet mash and for drinking purposes.

FFFECT OF DIARRHEA ON GROWTH AND DEVELOPMENT.

The effect of diarrhea on growth and development for the first eight weeks may be studied in the following table:

Table No. 5.

Date	Wt. of egg	Wt. at Hatch	Wt. 7 days	Wt. 14 days	Wt. 21 days	Wt. 28 days	Wt. 56 days	Diarrhea
5-13-15	.15	.10	.10	.22	.32	.32	.70	+
	.14	.09	.12	.17	.28	.24	.53	+
	.14	.09	.11	.17	.22	.21	.57	+
	.13	.10	.13	.20	.26	.26	.45	+
	.13	.08	.12	.19	.26	.32	.73	—
	.13	.09	.12	.16	.22	.23	.81	—
	.13	.09	.15	.20	.30	.32	.80	—
	.14	.09	.12	.20	.32	.38	.73	—

In these individual records of eight S. C. White Leghorns we find that four were affected with diarrhea and, although they survived at the end of eight weeks, the four that had suffered the attack averaged only 0.56 pound, while those that were not attacked averaged 0.74 pound.

In another lot of S. C. White Leghorns which was attacked by diarrhea during their first ten days, we note the following weights:

TABLE No. 6.

Date	Wt. of egg	Wt. at Hatch	Wt. 7 days	Wt. 14 days	Wt. 21 days	Wt. 28 days	Wt. 56 days	Diarrhea
4-2-15	.15	.10	.12	.19	.26	.31	.40	—
	.12	.08	.10	.15	.18	.18	.25	—
	.12	.10	.115	.16	.22	.30	.43	—
	.16	.10	.12	.20	.24	.31	.50	—
	.14	.08	.12	.19	.26	.31	.51	—
	.16	.10	.12	.21	.32	.39	.53	—
	.14	.08	.12	.20	.30	.42	.67	—
	.14	.08	.10	.13	.19	.21	.30	+
	.14	.085	.11	.17	.22	.24	.28	+
	.14	.07	.10	.15	.19	.20	.35	+
	.16	.09	.095	.15	.20	.26	.38	+
	.13	.09	.08	.11	.14	.15	.22	+
	.15	.09	.08	.11	.13	.13	.24	+
	.14	.09	.10	.14	.22	.20	.22	+
	.12	.08	.10	.14	.19	.24	.33	+
	.14	.10	.12	.18	.22	.27	.44	+
	.16	.09	.09	.14	.22	.29	.50	—
	.13	.09	.09	.13	.17	.18	.21	+
	.12	.08	.09	.12	.14	.18	.21	+

In a study of this table it is seen that 11 birds were attacked by diarrhea, and at the end of eight weeks averaged only 0.28 pounds each in weight. The eight birds which were not affected by diarrhea, averaged 0.47 pounds each in weight.

PART II

WHEN TO FEED THE BABY CHICK

A careful examination was made of 110 baby chicks to determine how much of the abdominal yolk was absorbed in the embryonic stage in the shell. In other words, an effort was made to determine how much food was left in the abdominal yolk at hatching.

THE ABDOMINAL YOLK.

The yolk as formed in the ovary of the hen has its origin in a minute sphere containing a nucleus. This nucleus marks the point of development of the embryo chick after fertilization. In its primary state the nucleus is located in the central portion of the cell or the primary ovum. When this cell or ovum begins the development of the yolk there is noted first a deposit of fine granules of yolk around the central nucleus. These granules of yolk material gradually extend towards the cell wall. The deposit being known as the latebra or the flask-shaped mass of white yolk forming thin layers upon layers of yellow yolk. Later, when the ovum has reached the size of 0.66 millimeters in diameter, the nucleus is noted to occupy a position just under the vitelline membrane and at the end of the flask-shaped mass. Later there is formed several layers of yellow yolk deposited around the central mass of white yolk, which is apparently brought about through the secretion of the peripheral layer of protoplasm.

In the formation of the embryo this yolk is incorporated in the abdomen and becomes the abdominal yolk and its membrane, the vitelline membrane, the abdominal yolk sac.

The weights were taken of 1,454 S. C. White Leghorn eggs. It was found that the average weight of these eggs was 57.7 grams. It was decided to determine the average weight of the yolks of the freshly laid egg. For the sake of accuracy it was determined to weigh the eggs, place them in boiling water and allow them to boil for ten minutes, then remove immediately and remove the yolk after first taking the weight of the egg upon being taken from the boiling water. It was thought that the boiling water would quickly coagulate the albumin and that there should be practically no loss or gain in weight. The following table gives the results:

TABLE No. 7.

Weight of Egg Before Boiling. Grams.	Weight of Egg After Boiling. Grams.	Weight of Yolk. Grams.
59	59	17.9
59	59	20.9
60	60	17
57	55	17.5
57	55	17.5
56	56	17.5
56	55	17.5
58	56	16.5
56	55	18.5
59	60	17
577	570	177.8

From an analysis of this table it will be seen that there was a loss through boiling of 0.7 gram, which makes the work close enough for practical purposes. It will also be noted that the average weight of these ten yolks was 17.78 grams, or a total weight of 177.8 grams.

Curtis[12] found that the average loss in weight of eggs, due to the evaporation that takes place through the pores of the shell, amounted to 0.04 gram to 0.13 gram daily for the first four days, with a mean for the first four days of 0.0893 grams. The loss in weight of the egg after it is laid depends on several factors, the principal ones being the humidity and temperature of the surrounding atmosphere, the rapidity with which the air around an egg changes, the amount of surface exposed, the size of the egg and the length of time which has elapsed since the egg was laid, and the size of the pores of the eggshell. Eggs kept in open air under certain conditions will lose as much as 15 to 24 grams in two days.

A hot egg weighed immediately on being taken from the boiling water will weigh a trifle more than if it be allowed to cool, and the time of weighing after being taken from the boiling water makes 1 to 2 grams difference in weight. Curtis found the mean weights of 14 yolks from eggs boiled to be 16.39, and from 15 eggs not boiled but separated in a fresh state, to be 16.82. There is no definite relation between the weight of the egg and the weight of the yolk. Thus one egg weighing 67.59 grams had a yolk that weighed 18.76 grams, and an egg weighing 72.47 grams had a yolk weighing 18.21 grams. In general it is found that the heavy eggs have a smaller percentage of yolk than the lighter ones.

In a study of ten baby chicks that had started to pip out of the shell but had died, it was found that the unabsorbed yolk weighed, on an average, 8.5 grams, or 47 per cent unabsorbed. There appeared to be no constant definite weight of the amount of yolk left in the yolk sac unabsorbed at this period of the chick's life. The weights varied from 8 to 10 grams.

It was found that the rate of absorption of the yolk varied in different individuals. One hundred and ten chicks were studied, and of these 40 were killed by aid of chloroform at different ages, skinned, and the carcasses immediately placed in a ten per cent solution of formaldehyde. Later these carcasses were sectioned longitudinally for the purpose of making a study of the relation of visceral organs with respect to the abdominal yolk sac.

Fig. 1 shows a section of a baby chick that has just hatched. The yolk fills approximately all of the abdominal cavity, pushing the abdominal visceral organs forward against the thoracic cavity.

Fig. 2 shows a longitudinal section of a baby chick 24 hours old. It will be noted that some of the abdominal yolk has been absorbed and that the gizzard, No. 2, as well as the intestines, have settled back toward their normal positions.

Fig. 3 shows a specimen that was dissected when 43 hours of age. No. 1 shows the abdominal yolk sac, which weighs 5 grams. That is, in this chick in 43 hours there was absorbed 3.5 grams on the assumption that the yolk originally weighed 8.5 grams.

Fig. 4 shows still further absorption of the yolk and represents a chick 48 hours old. In this chick the gizzard has taken its normal posi-

tion just posterior to the back point of the sternum. The intestines and liver are still forced forward.

Fig. 5 represents a chick 60 hours old allowing all organs to assume their normal position except the intestines.

Fig. 6 represents the dissected viscera of a chick 77 hours old. At No. 1 will be noted the abdominal yolk sac which in this individual still contained 3 grams of yolk. The yolk sac in No. 6 appeared much paler than in No. 3. There is apparently a more rapid loss of the fatty parts containing the lipochrome than of the white portion. In Nos. 3 and 6 can be seen (at 2) the vessel connecting the blood vessels of the somatic umbilicus to the abdominal yolk sac. This supply of nutrients is drawn upon by the vessels of the membranes of the embryo until the chick begins to pip, after which time the lungs begin to functionate normally and the vessel closes. At 3 will be noted a large vessel that communicates with the posterior portion of the small intestines, the short vessel of the yolk sac, and at 4 a smaller vessel that passes over to, and is lost in, the large mesenteric blood vessel, the long vessel of the yolk sac. Through these two vessels the abdominal yolk, which is apparently capable of being used without digestion, is supplied to the chick so that the nutritive processes may go on until it becomes strong and can care for itself and can take in food and digest it in the usual manner. In nature this is the time the brood is ready to leave the nest.

Fig. 7 is a section of a baby chick 84 hours old, and illustrates a case where absorption has been very rapid. All of the abdominal organs are in their normal position.

Fig. 8 illustrates a chick 95 hours old in which there is approximately as much abdominal yolk as in the one 84 hours old.

Fig. 9 is a section through a Houdan chick at 96 hours of age, in which there is a trifle more yolk than in Fig. 8.

Fig. 10 is a section of a chick at 108 hours old which absorbed its yolk much slower than the two preceding cases. It will be noted that part of the intestines are still forced forward.

Fig. 11 shows a baby chick at 120 hours of age. It will be noted that absorption of the yolk has been rather slow. This chick was very active and did not appear weak until after the 108th hour.

These baby chicks were kept in the nursery tray till all were killed. They were not given food or water, the object being to induce as rapid absorption of the liquid contents of the abdominal yolk as possible.

In these studies the birds were strong, and did not fail in vigor until after 100 hours old. After that time there appeared to be some absorption of the subcutaneous fat and the chicks did not appear so lively.

It will be seen that nature has made ample provision in supplying a generous store of food to keep the baby chick well nourished until the brood has hatched, and that this supply of nutrients is sufficient to carry nutrition on until the bird becomes strong. From the study of the rapidity of absorption of the abdominal yolk it appears clear that if baby chicks be fed as soon as hatched there is likely to be trouble. If the stomach, gizzard and intestines become gorged with food it is certain to place more or less pressure on the abdominal nerves and blood and lymph vessels, and thus the function of these vital structures will be interfered with and in some cases cause death.

Five experiments were run in which the baby chicks were left in the nursery tray until they were 72 hours old. They were then placed in outdoor brooders and given nothing but buttermilk to drink for the next 24 hours, and during the next 24 hours, or fifth day, were given only two light feeds with the milk, and after that time, or on the 6th day, they were placed on full feed. These chicks thrived better, were stronger and more resistant to chick troubles than their controls.

SUMMARY.

Normal, artificial buttermilk and sour milk are beneficial in baby chick feeding, serving to ward off severe attacks of diarrhea, and resulting in greater gains in the chicks.

It is recommended to feed sour milk as soon as the baby chick is taken from the incubator or nest.

Severe attacks of diarrhea interfere with the growth and development of those chicks which survive.

It is conducive to the best results to leave the baby chicks in the nursery tray until they are 72 hours old before removing them to the brooder and feeding. On the first day their feed should consist of sour milk or buttermilk. On their second day in the brooder they should receive only light feed in addition to the milk. After that time they may with safety be placed on full feed.

In the case of sitting hens it is advisable to give milk the first day after taking the hen from the nest and light feed for the next two days, after which they may be placed on full feed with safety.

By using the combination sitting and brooding coops the hen may be fed from a high can, as an oyster can, and the baby chicks fed in their compartment, just what is desired, and without being interfered with by larger fowls or the mother.

BIBLIOGRAPHY

[1]Bulletin No. 100. Oregon Experiment Station. Dryden.
[2]Bulletin No. 103. Oregon Experiment Station. Pernot.
[3]Bulletin No. 60. Storrs Experiment Station. Rettger and Stoneburn.
[4]Bulletin No. 74. Storrs Experiment Station. Rettger and Kirkpatrick.
[5]Bulletin No. 185. Colorado Experiment Station. Kaupp.
[6]Diseases of Poultry and Their Treatment. Am. Jr. Vet. Med. Kaupp.
[7]Bulletin No. 168. Maine Experiment Station. Pearle and Surface.
[8]General Bacteriology. W. B. Saunders Co., Phila. Jordan.
[9]Journal of Infectious Diseases, Vol. 16, No. 2. Kite and Wherry.
[10]Journal of Infectious Diseases, Vol. 16, No. 3. Heinemann.
[11]Veterinary Bacteriology. W. B. Saunders Co., Phila. Buchanan.
[12]Bulletin No. 191. Maine Experiment Station. Curtis.

DESCRIPTIONS OF THE ILLUSTRATIONS

Fig. 1—Photograph. Antero-posterior section, through the median line, of a baby chick just hatched: 1, the abdominal yolk sac; 2, the gizzard; 3, the liver; 4, the heart; 5, the intestines; 6, the spinal cord; 7, the cerebrum; 8, the cerebellum; 9, fat in the occipital region.

Fig. 2—Photograph. Antero-posterior section through the median line of a 24-hour-old chick. The figures indicate the same organs as in No. 1.

Fig. 3—Photograph. The visceral organs of a baby chick 43 hours old: 1, the yolk sac; 2, the communicating vessel between the yolk sac and the somatic umbilicus; 3, the short vessel of the yolk sac communicating between the yolk sac and the last portion of the small intestines; 4, the long vessel of the yolk sac communicating between the yolk sac and the mesenteric vessels; 5, the mesentery; 6, the tongue; 7, the œsophagus; 8, the crop; 9, the second portion of the œsophagus; 10, the duodenal fold; 11, the gizzard; 12, the last portion of the intestines; 13, the large intestine or rectum; 14, the somatic umbilicus; 15, the liver; 16, the pancreas; 17, the lungs; 18, the heart; 19, the gall bladder.

Fig. 4—Photograph. Antero-posterior section through the median line of a baby chick 48 hours old. Figures 1 to 9 inclusive are the same as in Fig. 1. 10, proventriculus; 11, the second portion of the œsophagus; 12, the lung, which shows the manner in which it pushes between the ribs; 13, the rectum terminating into the cloaca.

Fig. 5—Photograph. Antero-posterior section through the median line of a baby chick 60 hours old. Figs. 1 to 8, inclusive, are the same as in Fig. 1. 9, the proventriculus; 10, the second portion of the œsophagus terminating into the proventriculus.

Fig. 6—Photograph. Visceral organs of a baby chick 77 hours old. Figures are the same as in No. 3.

Fig. 7—Photograph. Antero-posterior section through the median line of a baby chick. Figures are the same as in Fig. 4; 84 hours old.

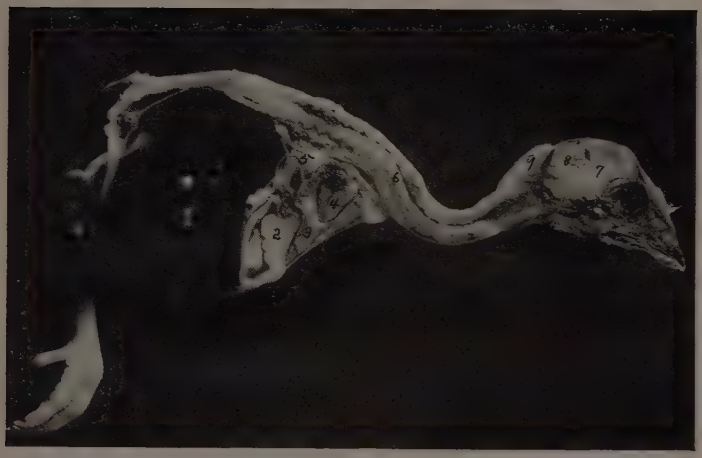
Fig. 8—Photograph. Antero-posterior section through the median line of a baby chick 96 hours old. Figures same as No. 4.

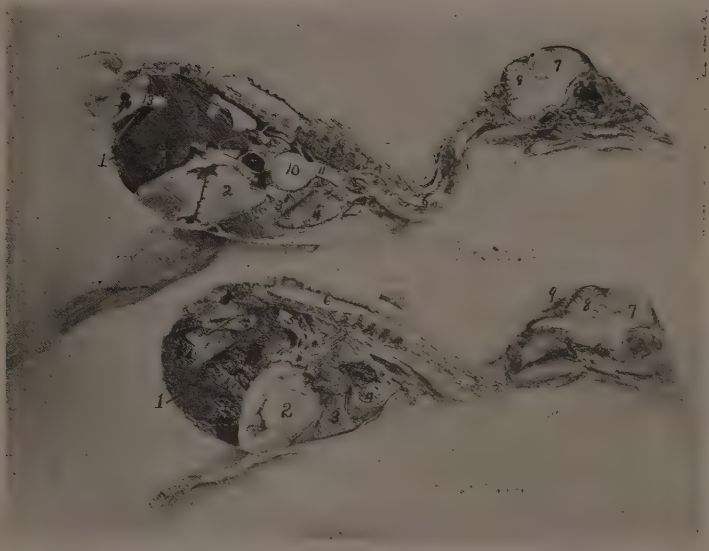
Fig. 9—Photograph. Same as No. 8, and figures the same as in Fig. 4.

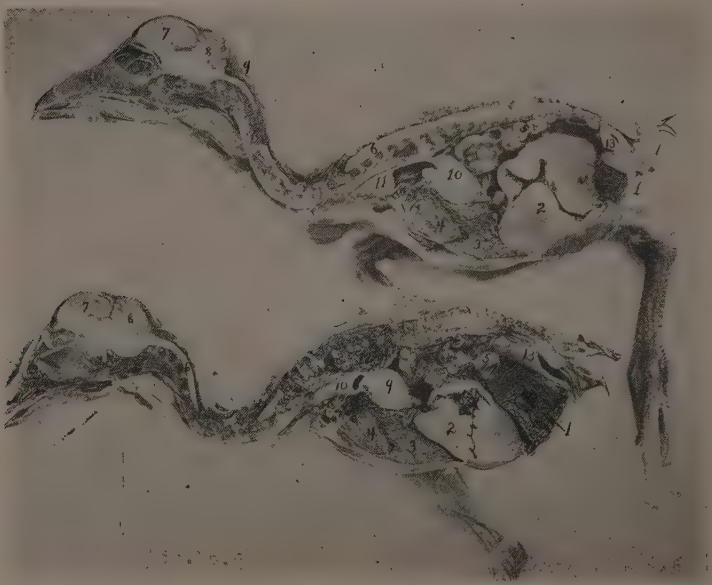
Fig. 10—Photograph. Antero-posterior section through the median line of a baby chick 108 hours old. The figures are the same as in No. 4.

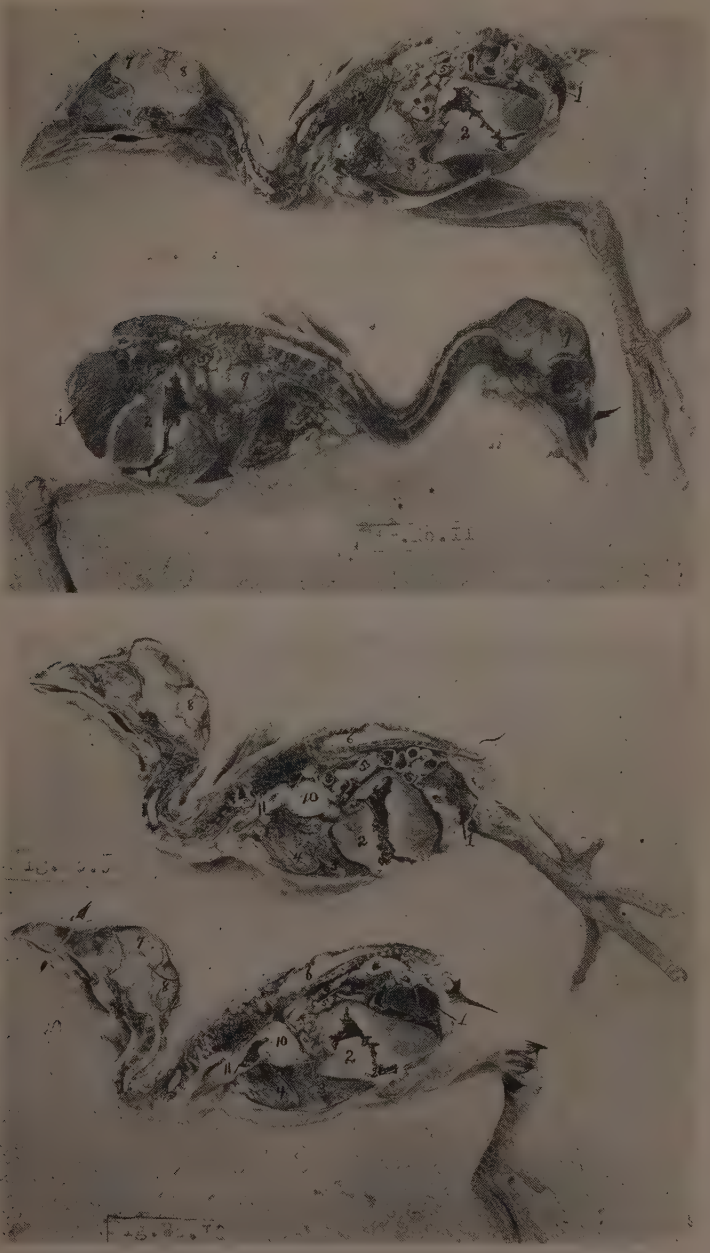
Fig. 11—Photograph. Antero-posterior section through the median line of a baby chick 120 hours old. The figures are the same as in No. 4.

Fig. 12—Photograph of a chick that had partially pipped out of the shell and died: 1, is a somatic umbilical hernia (rupture) caused by excessive straining to free itself from the shell; 2, the umbilical ring.


2
4
5
7
8
9


1
2
7
8
9
10
11
1
2
3
7
8
9





FEBRUARY, 1916 BULLETIN 236

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

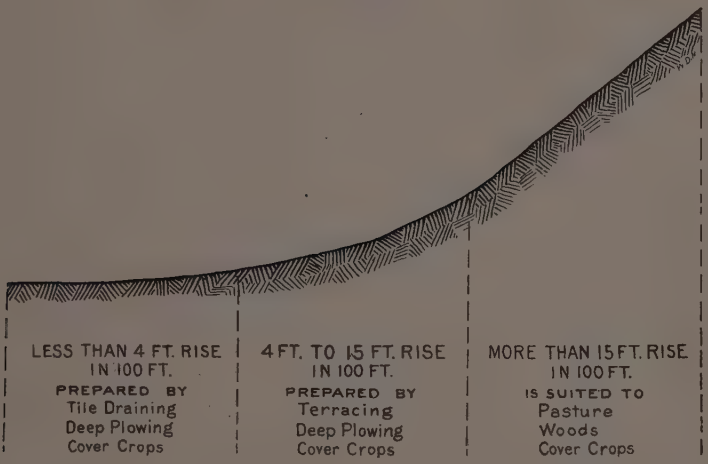
CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE

AND THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

RALEIGH AND WEST RALEIGH



The relation of slope to the preparation of farm lands in preventing erosion.

The Prevention and Control of Erosion in North Carolina, with Special Reference to Terracing

By F. R. BAKER
Assistant Drainage Engineer

Bulletins of the Station Will be Sent Free to Citizens of the State on Request

THE NORTH CAROLINA AGRICULTURAL EXPERIMENT STATION

CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE

AND THE

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS

BOARD OF AGRICULTURE

*W. A. Graham, *Chairman*, Raleigh

F. P. Latham	Belhaven	*A. T. McCallum	Red Springs
C. W. Mitchell	Aulander	*C. C. Wright	Hunting Creek
*R. L. Woodard	Pamlico	William Bledsoe	Gale
*Clarence Poe	Raleigh	W. J. Shuford	Hickory
R. W. Scott	Haw River	A. Cannon	Horse Shoe

BOARD OF TRUSTEES OF THE COLLEGE

Governor Locke Craig, *Chairman*.

M. B. Stickley	Concord	*T. T. Thorne	Rocky Mount
T. T. Ballinger	Tryon	*C. W. Gold	Greensboro
W. H. Williamson	Raleigh	T. E. Vann	Como
O. L. Clark	Clarkton	P. S. Boyd	Mooresville
Everett Thompson	Elizabeth City	W. E. Daniel	Weldon
R. H. Ricks	Rocky Mount	*W. H. Ragan	High Point
O. Max Gardner	Shelby	W. B. Cooper	Wilmington
M. L. Reed	Biltmore	J. P. McRae	Laurinburg

*D. H. Hill (President College), West Raleigh.

STATION STAFF

B. W. Kilgore, Director
C. B. Williams, Vice-Director
R. W. Collett, Asst. Director, Branch Stations
F. H. Jeter, Agricultural Editor
Miss Mary S. Birdsong, Sec'y to Director
C. B. Williams, Chief in Agronomy
J. K. Plummer, Soil Chemist
W. F. Pate, Agronomist—Soils
E. C. Blair, Assistant Agronomist—Soils
H. D. Lambert, Assistant Agronomist—Soils
R. Y. Winters, Plant Breeding
[1]Buxton White, Assistant in Plant Breeding
[1]V. R. Herman, Assistant in Plant Breeding
[2]W. E. Hearn, State Soil Agent, Soil Survey
[2]R. B. Hardison, Assistant in Soil Survey
S. O. Perkins, Assistant in Soil Survey
L. L. Brinkley, Assistant in Soil Survey
F. N. McDowell, Assistant in Soil Survey
[2]E. S. Vanetta, Assistant in Soil Survey
A. R. Russell, Assistant in Field Experiments
W. A. Withers, Chemist
F. E. Carruth, Assistant Chemist
H. L. Cox, Assistant Chemist
J. M. Pickel, Feed Chemist
W. G. Haywood, Fertilizer Chemist
J. Q. Jackson, Assistant Chemist
E. S. Dewar, Assistant Chemist
E. B. Hart, Assistant Chemist
F. C. Wiggins, Assistant Chemist
Franklin Sherman, Jr., Chief in Entomology
Z. P. Metcalf, Entomologist
S. C. Clapp, Assistant Entomologist
R. W. Leiby, Assistant Entomologist
W. N. Hutt, Chief in Horticulture
J. P. Pillsbury, Horticulturist
L. R. Detjen, Assistant Horticulturist
R. G. Hill, Assistant Horticulturist
C. D. Matthews, Assistant Horticulturist

B. Szymoniak, Demonstrator in Fruit and Truck Crops
Dan T. Gray, Chief in Animal Industry
R. S. Curtis, Associate in Animal Industry
W. H. Eaton, Dairy Experimenter
B. F. Kaupp, Poultry Investigator and Pathologist
[3]A. J. Reed, Dairy Farming
[3]J. D. McVean, Pig Club Agent
[3]A. G. Oliver, Poultry Club Agent
Stanley Combs, Assistant in Dairy Farming
[3]J. A. Arey, Assistant in Dairy Farming
[3]F. R. Farnham, Assistant in Dairy Farming
[3]J. L. Graybill, Assistant in Dairy Farming
[3]F. T. Peden, Assistant in Beef Cattle
[3]A. L. Jerdan, Assistant in Beef Cattle
[3]L. I. Case, Assistant in Beef Cattle
Earl Hostetler, Assistant in Beef Cattle and Swine
Dan M. McCarty, Assistant in Animal Nutrition
F. A. Wolf, Plant Pathologist
R. O. Cromwell, Assistant, Plant Diseases
[4]H. M. Lynde, Senior Drainage Engineer
F. R. Baker, Assistant Drainage Engineer
[1]C. R. Hudson, Farm Demonstration
[1]T. E. Browne, Asst. in Charge Boys' Clubs
[1]Mrs. C. McKimmon Assistant in Charge Girls' Clubs
[1]A. K. Robertson, Assistant in Boys' Clubs
[1]Miss Minnie L. Jamison, Assistant in Home Economics
G. A. Roberts, Veterinarian
W. R. Camp, Marketing
[1]J. M. Johnson, Farm Management
[1]E. H. Matthewson, Tobacco Expert
A. F. Bowen, Bursar

F. T. Meacham, Assistant Director Iredell Branch Station, Statesville
J. H. Jefferies, Assistant Director Pender Branch Station, Willard
C. E. Clark, Assistant Director Edgecombe Branch Station, Rocky Mount
[1]E. G. Moss, Assistant Director Granville Branch Station, Oxford
S. F. Davidson, Assistant Director Buncombe and Transylvania Stations, Swannanoa

The members marked with * are members of the Joint Committee for Agricultural Work, and the Station is under their direction.

[1]In cooperation with the U. S. Department of Agriculture, Bureau of Plant Industry.
[2]In cooperation with the U. S. Department of Agriculture, Bureau of Soils.
[3]In cooperation with the U. S. Department of Agriculture, Bureau of Animal Industry.
[4]In cooperation with the U. S. Department of Agriculture, Office of Public Roads and Rural Engineering.

CONTENTS

PAGE

Introduction 5
Location and Extent of Area Especially Subject to Erosion 5
Nature and Cause of Erosion 7
Can Eroded Areas be Reclaimed? 8
Prevention of Erosion 9
- Proper Cultivation 10
- Tile Drainage 11
- Hillside Ditches 12
- Terraces 12
  - The Falling Terrace 13
  - When and How to Lay Off a Falling Terrace 13
  - The Level Terrace 20

Filling Gullies 22
Useful Accessories:
- The Farmer's Level 22
- A Home-made Level 23
  - How to Use the Level 24
- The "A" Frame Level 25
- The Terrace Drag 26

Conclusion 26

ILLUSTRATIONS

		PAGE
	The Relation of slope to the preparation of farm lands in preventing erosion	*Frontispiece*
FIG. 1.	Map of North Carolina, showing area especially affected by erosion	6
FIG. 2.	An eroded field; a common sight in North Carolina	7
FIG. 3.	Showing how a low place should be built up by a terrace crossing	8
FIG. 4.	The same place as shown in Fig. 3; view taken some time later, and showing complete reclamation of the low place	9
FIG. 5.	A field, once badly eroded, reclaimed by terraces	10
FIG. 6.	Building a terrace. The first step is to stake off the terrace	14
FIG. 7.	The second step is to plow a deep back furrow along the line of stakes	14
FIG. 8.	The third step, resulting in a plowed strip 12 feet wide	15
FIG. 9.	The fourth step is to use the terrace drag	16
FIG. 10.	The completed terrace—from 16 to 20 feet wide	17
FIG. 11.	A poor outlet	18
FIG. 12.	A good outlet	18
FIG. 13.	A terrace design for farm in Cabarrus County, N. C.	19
FIG. 14.	A terrace design for farm in Halifax County, N. C.	20
FIG. 15.	Showing construction of terraces on a farm in Halifax County, N. C.	21
FIG. 16.	Level bench terrace	21
FIG. 17.	Showing how to arrange the tile and the dam in a gully	22
FIG. 18.	A simple farmer's level	23
FIG. 19.	A home-made level	24
FIG. 20.	The use of the level in laying out terraces	24
FIG. 21.	"A" frame used with plumb bob	25
FIG. 22.	"A" frame used with carpenter's level	25
FIG. 23.	Rectangular frame used with carpenter's level	25
FIG. 24.	The terrace drag	26

THE PREVENTION AND CONTROL OF EROSION IN NORTH CAROLINA, WITH SPECIAL REFERENCE TO TERRACING

Introduction.

The conservation of our greatest asset, the soil, is essential to the welfare of the people of North Carolina. Every drop of rain falling has in it the power to move a particle of soil. This soil is taken from our fertile fields and finally deposited in the lowlands and in the drainage channels. Thus the action of erosion not only destroys the fertility of the hillside lands and disfigures those lands with gullies, but it is also in a large measure the cause of the continual overflow of our streams with disastrous results to crops on the bottom lands. The formation of soil is necessarily a slow process, and what nature has done in centuries a single storm can undo in minutes.

Owing to her topographical and geological conditions, North Carolina has a large area affected by erosion, and by reason either of carelessness or of ignorance the damage from this source has been great; yet facts show that this erosion can be prevented, and, with proper care exercised at the right time, can be entirely stopped at a relatively small cost. Vegetation, humus in the soil, and terraces are means of preventing erosion, the latter preventive being the subject with which this bulletin is chiefly concerned.

The matter of soil preservation is one that is receiving more and more attention by the landowners of the State, and it was with the purpose of answering the many questions concerning the subject that this bulletin was prepared.

Location and Extent of Area Especially Subject to Erosion.

With reference to topography, the State of North Carolina is divided into three distinct sections:

1. The Coastal Plain region, extending from the Atlantic Ocean to a line roughly passing through the counties of Halifax, Franklin, Johnston, Wake, Moore, Richmond, and Anson; the topography of this region ranges from level to rolling.
2. The Piedmont Plateau region, extending from the above mentioned line to the foot of the western mountains, the topography of which ranges from rolling to hilly.
3. The Mountain region, which, as its name implies, includes the mountains of Western North Carolina.

Note.—In accordance with an agreement between the U. S. Department of Agriculture and the North Carolina Department of Agriculture, the Federal Department has for several years maintained in North Carolina a drainage engineer who is assisted by an engineer provided by the State Department of Agriculture, for the purpose of promoting the practice of farm drainage in the State. This bulletin has been prepared under this coöperative agreement.

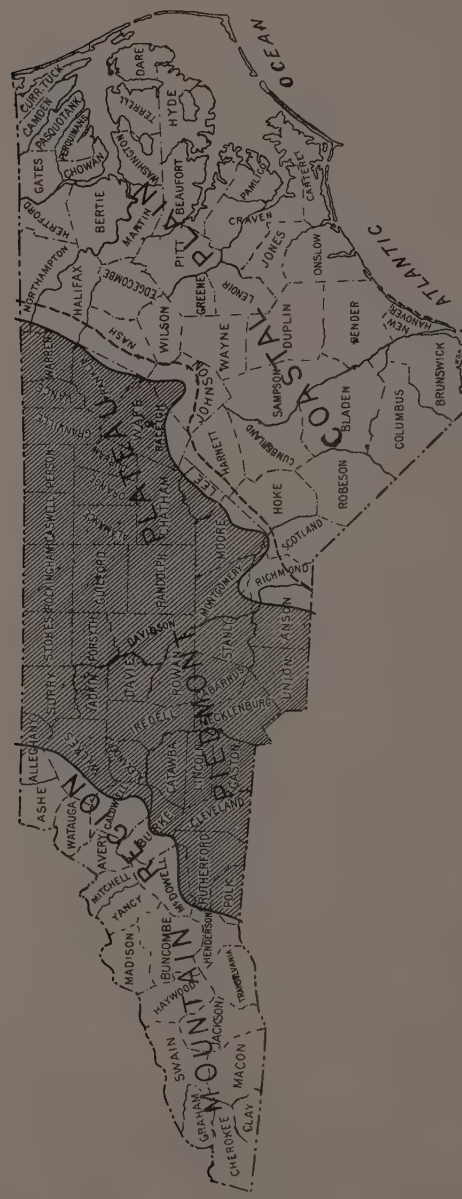


Fig. 1. North Carolina, showing area especially affected by erosion.

These three divisions of the State are shown on the accompanying map of North Carolina (figure 1). It is almost wholly within the Piedmont region that erosion is especially active, due to the steep slopes and to the presence of clay soils that are low in humus and of a fine-grained texture. However, a considerable amount of the western Coastal Plain may be included in the area subject to erosion; this area is that west of the dotted line in figure 1. It can readily be seen what it means to the individual and to the State when it is realized that the area so affected covers over 10,000,000 acres of land. Its preservation constitutes an obligation which the people of the State cannot afford to neglect, and which must be fulfilled before the maximum earning capacity of the State can be attained.

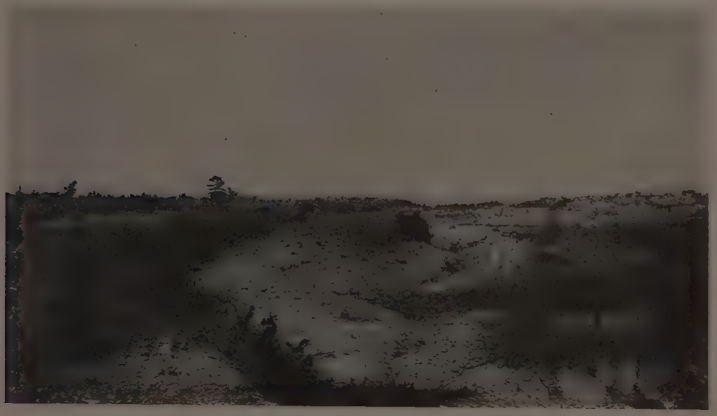


FIG. 2. An eroded field; a common sight in North Carolina.

NATURE AND CAUSE OF EROSION.

Since erosion is the direct cause of much waste, it is well to know what it is and how it is caused. Erosion is the carrying away of the particles of soil by flowing water, leaving rough and irregular places commonly known as gullies. Figure 2 shows a typical case of erosion in North Carolina, in which an attempt has been made, by the use of brush, to prevent further action of this nature.

The principal cause of erosion is the rainwater, which flows over the surface in little *uncontrolled* streams, cutting deeper and deeper into the soil as the quantity and velocity of the water increases. Attention is called to the fact that erosion is most active in open, cultivated fields, for the rain falling in the forests is prevented from washing by the protective covering of leaves, by the absorptive power of a soil rich in humus, and by the action of the network of rootlets in binding the soil together. On the other hand, rain falling on an unprotected soil

containing little humus packs the surface, preventing the water from being absorbed and causing it to run over the ground, cutting little channels that soon grow into large gullies. This difference in the susceptibility of soils to erosion may be demonstrated by taking two boxes filled with soil, one from a barren spot and the other from a rich loam. Incline the boxes, pour water over the surface and note the results. The water poured on the humus soil will soak in, but that poured on the poor soil will soon compact the surface and begin running down over the surface, washing it badly.

Neglecting evaporation, all of the water which falls on the land either soaks in or flows over the surface; if all the water could be absorbed there would be no erosion, consequently no muddy streams. However,

Fig. 3. Showing how a low place should be built up by a terrace crossing. Note the bank and pond of water (x).

conditions in North Carolina are unfavorable for complete absorption, and experience has shown that it is almost impossible of attainment. Mechanical means must, therefore, be resorted to in order to conduct the excess water from the surface in such a manner that no damage shall be done.

Can Eroded Areas be Reclaimed?

The great number of abandoned fields in North Carolina indicates that common opinion would answer in the negative; however, practice has shown that these eroded areas which have been abandoned can be reclaimed. As noted above, the cause of erosion is simple; so likewise is the remedy, but it takes patience and time. Unfortunately, many of the so-called terraces found in various sections defeat the purpose for which they were intended, and efficient terraces, properly constructed and maintained, are infrequent; nevertheless, there are in North Carolina some well-terraced fields which show conclusively the great economic value of a terrace properly constructed.

Figures 3 and 4 clearly show what reclamation will do. These pictures were taken on the A. & M. College farm at West Raleigh. Note the gully which was 6 feet in depth. By proper care and management it was made to yield results equal to those on any other portion of the farm.

Figure 5 is a view taken on a farm near Wake Forest, which formerly suffered severely from erosion. The owner has now reclaimed the farm by means of terraces. No better argument than that of pointing out existing examples is needed to prove that these waste areas can be economically reclaimed.

FIG. 4. The same place as shown in Fig. 3; view taken some time later, and showing complete reclamation of the low place. The cultivated area in the foreground is the old pond, (x), Fig. 3.

PREVENTION OF EROSION.

Since erosion is due to the rapid flow of accumulated water which has not been absorbed by the soil, it may be lessened by any means which will promote absorption and lessen the rapidity of the run-off. These ends can be accomplished by the following methods, all of which have been found by experience to be more or less effective:

1. Proper cultivation.
2. Tile drainage.
3. Hillside ditches.
4. Terracing.

Having these several methods to select from, the natural question for the individual to decide is, which is the method that can be afforded and that will give the results wanted. We must keep in mind, how-

ever, that the nature of the area to be treated determines to a certain extent the kind of protection best suited. The four methods are discussed in the following pages.

Proper Cultivation.

This method is simply the intelligent handling of the soil at all times, having in mind the particular result desired. It has been pointed out that the objects sought in the prevention of erosion are to conduct

Fig. 5. A field, once badly eroded, reclaimed by terraces (original Mangum type). Note that no planting space is lost. (From Circular 94, U. S. Bureau of Plant Industry.)

the water into the soil, and over the soil. The former is the one which concerns us here, i. e., to prepare the soil in such a way that it will absorb as much water as possible; that which is not taken up must be conducted slowly over the surface. Absorption can be increased by deep and thorough plowing, and by increasing the amount of humus in the soil either by barnyard manure, by turning under vegetation, or by the use of cover crops.* The object is to make the soil and subsoil like a vast sponge, quick to absorb and efficient to retain the water as long as necessary. To do this perfectly will of course require ideal conditions and, especially, a small rainfall. Here in North Carolina,

*Information on the subject of deep tillage and cover crops can be obtained by application to the North Carolina Experiment Station at West Raleigh.

where the annual rainfall is large (about 50 inches) and where heavy rains are frequent, we are safe in assuming that this method alone will not be sufficient, and that some artificial method of controlling the water on the surface must be adopted. The reader should not be misled here, however, and conclude that if other methods are adopted, proper cultivation need not be practiced. It is the progressive and scientific farmer who will adopt both methods, the one to add to and build up the soil and the other to remove the surplus water.

TILE DRAINAGE.

Tile drainage is naturally associated with the level areas where erosion is not serious, but recently some authors have advanced the idea that tile drainage will prevent erosion. Tile drainage will promote absorption and filtration by loosening the soil to a greater depth than can be reached by cultivation. The principles of design and construction of tile drains for this purpose are the same as those involved in the drainage of wet lands. Catch wells, properly located over the surface, will help to take up the excess water, acting similarly to the catch basins that we see at the corners of streets in our modern cities. However, the cost of this method, considered solely as a means of preventing erosion, will be almost prohibitive; this is probably the most serious argument that can be used against it. Dr. W. I. Chamberlain well illustrates the absorptive power of the tile-drained land when he says, in part:

> I have spoken of the fact that the soil on my farm absorbed and filtered and my drains carried away about ten inches of rainfall in February and March, 1891, with no surface wash, gullying or loss of fertility. I have been again reminded of the great absorbing power of a tile-drained soil. We are plowing a 36-acre field of wheat across three plats, one timothy, one wheat-stubble thick with young clover, and one heavy clover where wheat was harvested. Tuesday, August 11, the ground was rather hard to plow, driest in the strong clover turf and next driest in the timothy turf, dampest in the stubble and young clover. Tuesday noon, exactly one inch of rain fell in about an hour, soon followed by 0.26 of an inch, and on Friday by 0.91 of an inch; total, 2.17 inches. The ground took it all in as fast as it came. The first inch did not soak down over three inches into the clover turf not yet plowed, and the whole 2.17 simply soaked down about seven inches and made it scarcely damp enough to plow best.

Judging from this, the soil would probably have held 1 or 2 inches more before surface wash would have begun, if at all, as the tile had not begun to work even after two inches of rainfall. We can readily see the relation that tile drainage bears to the soil and rainfall in that the soil is transformed by drainage into a vast sponge which gives up the water to the tile when it is "squeezed," that is, pressed by excess water from higher land or by rainfall. It should be noted, however, that Dr. Chamberlain's experience was in a field with cover crops. The

results probably would not have been the same if the field had been in clean-cultivated crops as are common in North Carolina.

It may be said in conclusion that, principally owing to its cost, and to our concentrated rainfall, the method of tile drainage is not at present considered to be a practical means of preventing erosion in North Carolina.

Hillside Ditches.

One of the most common sights on the hillside is the open ditch. Investigations and observation lead to the conclusion that ditches often aid to a certain extent the action of erosion, and, therefore, in many cases should be abandoned. These ditches are usually poorly located and are maintained at a great expense; they occupy valuable space, harbor insects and weeds which are scattered broadcast by the wind and by every turn of the plow or cultivator, and, above all, they usually hinder a healthy plant growth by taking away the rainfall too quickly.

On account of these many objectionable features, the ditch should not be used except as an outlet. In many cases it is found necessary to construct a ditch to receive the discharge from the terraces.

Terraces.

Many kinds of terraces can be seen in North Carolina. For simplicity, they will, in this discussion, be divided into two classes, the falling terrace and the level terrace.

The falling terrace is so named from the fact that it has a definite fall or grade toward the outlet. The level terrace has no such grade, being designed to absorb all the water that falls upon it.

It is generally found that where one type of terrace has proved successful, it creates a circle of influence and most other terraces in the neighborhood are similar to it; this accounts for the groups of similar terraces found in different sections. For instance, in one county or township, all of the terraces are likely to be falling terraces, while in another county, all may be level terraces. It is impossible to divide the State into sections and to assign different types of terraces to different sections, for the kind of terrace desirable depends largely upon the physical condition of the soil. Level and falling terraces may well be constructed on adjacent farms. The lands most needing terracing are the poor and wornout ones; and the higher the state of cultivation, the less the fall that need be given.

Wherever practicable, the terrace should consist of a broad mound so that there shall be no lost planting space and no bank to harbor weeds, and no trouble to get a team from one terrace to another. The use of this broad terrace should be of general interest, as the future use of labor-saving machinery is more or less dependent upon the cultivation of the land in larger and less irregular bodies.

The Falling Terrace.

The falling terrace is one commonly known in North Carolina as the Mangum terrace (figure 5.) This terrace is simple in construction and permanent in character, and is adapted to slopes of less than 15 feet rise to 100 feet horizontal distance. It consists of a broad, low mound about 8 to 10 feet wide and from 1 to 2 feet high, with a shallow ditch from 8 to 10 feet wide on the upper side. The principle of the terrace is to conduct the water away in a thin sheet with a small velocity, thus lessening its erosive effect and permitting most of the soil and fertilizer to remain. It is very important that it be built on a uniform, proper grade and that a correct vertical distance between terraces be given in order that the water may pass off in small quantities and with a uniform low velocity.

The fall per rod as recommended by different workers varies from $\frac{1}{2}$ inch to $1\frac{3}{4}$ inches. From the best available information it is believed that a fall of 1 inch per rod or 6 inches to the hundred feet will give good results. The vertical distance between terraces varies from 3 to 6 feet. The proper fall and vertical distance will depend upon the slope of the surface, the character of the soil, and, to some extent, upon the length of the terrace and the height of the bank. It is best to have a short terrace, as the accumulation of water will not be so great and the danger of breaking will be lessened.

Experience so far indicates that a vertical distance of 4 to 5 feet between terraces on any slope within the limits of use of the terrace gives satisfactory results. This necessarily gives different horizontal distances between terraces, the greatest distance being on the lesser slope; hence each terrace has a different sized watershed from which to discharge. For the vertical distance to be used between terraces the following is applicable: When the slope of the surface ranges from 3 to 6 feet in 100 feet, space the terraces 4 feet apart (vertical distance), and when the slope ranges from 6 to 15 feet, make the spacing 5 feet. A uniform slope is seldom found in the Piedmont section of North Carolina. Often the topography on a field ranges from gently rolling to very steep. On such fields the horizontal distances between terraces would vary; to avoid extreme variation it may be advisable to use different vertical spacings in the same field. It is believed that this type of terrace is the one best adapted to most conditions that exist in the State.

When and How to Lay Off a Falling Terrace.

The so-called "idle" period of the year is, for financial reasons, the best time to construct terraces. It is preferable to construct them just after harvesing time, so that the terraces can be fairly well established before the next crops come.

Often there are large areas needing terraces and one can not afford to complete them at one time. If this be true, the work should begin

at the top of the hill, completing each terrace before leaving it, and thus providing against danger from accumulated water above. Much depends upon the judgment and care in locating the first terrace, or the one at the top of the hill; it should be so located that very little water from above will have to be cared for.

Fig. 6. The first step is to stake off the terrace.*

Fig. 7. The second step is to plow a deep back furrow along the line of stakes.

Before a system of terraces can be properly designed, it is necessary to determine where the flow from them may be discharged. A natural stream should be used if such is available. Terraces are often made to discharge upon the ground in the woods. There may be no damage from such arrangement, but many times the future may bring the desire to clear the woodland and cultivate that area. Then the owner may be put to considerable inconvenience and expense to adapt his terrace system to another outlet. As stated above, terraces should not be too long, and, in order to give them the least possible length, they should discharge in a direction more or less opposed to that of the flow in the outlet channel. It is not good practice to make the terraces over 1,500 feet in length. There are instances, however, of terraces 2,000 feet in length which have given satisfactory results, but one of this length requires more attention than a shorter one. It is the opinion

*For the development of a terrace see figs. 6, 7, 8, 9 and 10.

of the writer that a length of from 300 to 1,000 feet would be decidedly preferable.

In cases where the slope is very long paralleling a stream, it is puzzling to know where to empty the water from the terrace. If a

FIG. 8. The third step, resulting in a plowed strip twelve feet wide.

shallow ditch along a road is not available, a ditch down the slope in a suitable place is necessary. Care must be exercised, however, that this ditch does not enlarge into a gully. A lining of boards or half of a large sewer pipe in the bottom will prevent this. The sides of the ditch can be sodded and kept clean.

After the locations have been determined upon, it is well to stake the terraces off by placing small stakes or straws every 50 feet along the line of the terrace, giving the proper fall for every 50-foot stake (figure 6). The advantage of placing the stakes before plowing lies in

the fact that a better line can be secured with easy curves and no sharp bends. To stake off a terrace properly, one must equip himself with a 50-foot tape, a level, and a rod. It is well to have a level on the farm, as it can be used in a variety of ways and is by far more accurate and rapid than "A" frames. The use of the level in staking off a terrace will be treated later under "How to Use a Level."

The writer has found that, to avoid confusion, and probably errors, it is best to first establish a point on each terrace, which can be done by running a line of stakes down the slope, giving the proper vertical

Fig. 9. The fourth step is to use the terrace drag.

fall between them. It has also been found best to run this line of stakes down the *center* of the slope that is to be terraced and not at the end or beginning of the terraces. Practice has shown that this precaution will, to a great extent, eliminate the tendency of the terraces to get too far apart at the ends, and will keep them more or less parallel. This done, the next step will be to back the terrace up the hill to the beginning, and then down the hill to the outlet, in each case giving the proper fall between adjacent 50-foot stakes. The method just described applies especially to those who are acquainted with the use of a level, for they can determine exactly where the terrace will run; in case one can not use the level and desires to have the terrace discharge at a certain point, it is best for him to begin at that point and work up hill.

It is very important to have the ends of the terraces protected in case they discharge into a ditch. The danger here is in washing back and can be overcome by allowing the water to discharge over boards or

through pipes, in each case giving a free over-fall into the ditch. Figure 11 shows what may be expected if proper attention is not given to the question of outlet. Figure 12 shows a serviceable oulet.

Next follows the actual construction of the terrace. The only implements necessary for this are a two-horse plow and a terrace drag (figure 24); if a road scraper is available it is even better than a terrace drag. In the case of the average farmer it will take about two years

FIG. 10. The completed terrace—from sixteen to twenty feet wide.

to establish a good, reliable terrace, and for this reason the following instructions are given.

The First Year:

With the plow follow the lines as staked off, making all curves easy (fig. 7). With this furrow as a center line, throw up a back furrow strip on each side about 6 feet wide (fig. 8). This will mean about six furrows on each side, resulting in a terrace about 12 feet wide. This done, run the drag around on the lower and upper sides two or three times, letting the hinged portion of the drag follow loosely behind. This will give shape to the terrace by throwing the upper half down on the lower half, thus forming the ditch and the bank (fig. 9). Now repeat the dragging, having first added two more furrows on each side; this will give a terrace approximately 16 feet wide, which is wide enough for the first year (fig. 10).

The drag is now used with the hinged portion in place, so that the center of the terrace can be reached. The last furrow should be plowed

deep in order to keep the drag steady. After the bank thus formed has settled, it will be well to go over it again in order to get the terrace as high as possible, for the critical period of a terrace is during the first year, and especially after the first heavy rain. Do not be discouraged if the terrace breaks in several places at first, but immediately build up these weak places so that it will not occur again. Do not cultivate in furrows on the terrace this first year, but it is well to sow it down in peas, clover, oats, or rye. This will not only give a profit, but will

Fig. 11. A poor outlet.

Fig. 12. A good outlet.

help to keep the terrace from breaking. The rows should be plowed parallel with the terraces during the first year.

The Second Year:

Repeat the operation outlined above, but do not be satisfied until the terrace is nearly 20 feet wide, and remember that it is a permanent improvement and a good investment.

In the second year the rows can be run in almost any direction, but it is best to select such a direction so that the rows will cross the terrace at an angle. In plowing across the terrace, lift the plow slightly so that the terrace will not be weakened materially. If, in the judgment of the owner, the terrace does not appear to be strong enough, repeat the recommendations given for the first year. The terrace should be from 1 to 2 feet high.

Fgure 13 is a design for a field in Cabarrus County and shows ideal conditions for a terrace system. All terraces begin at the center of the tract and discharge on each side.

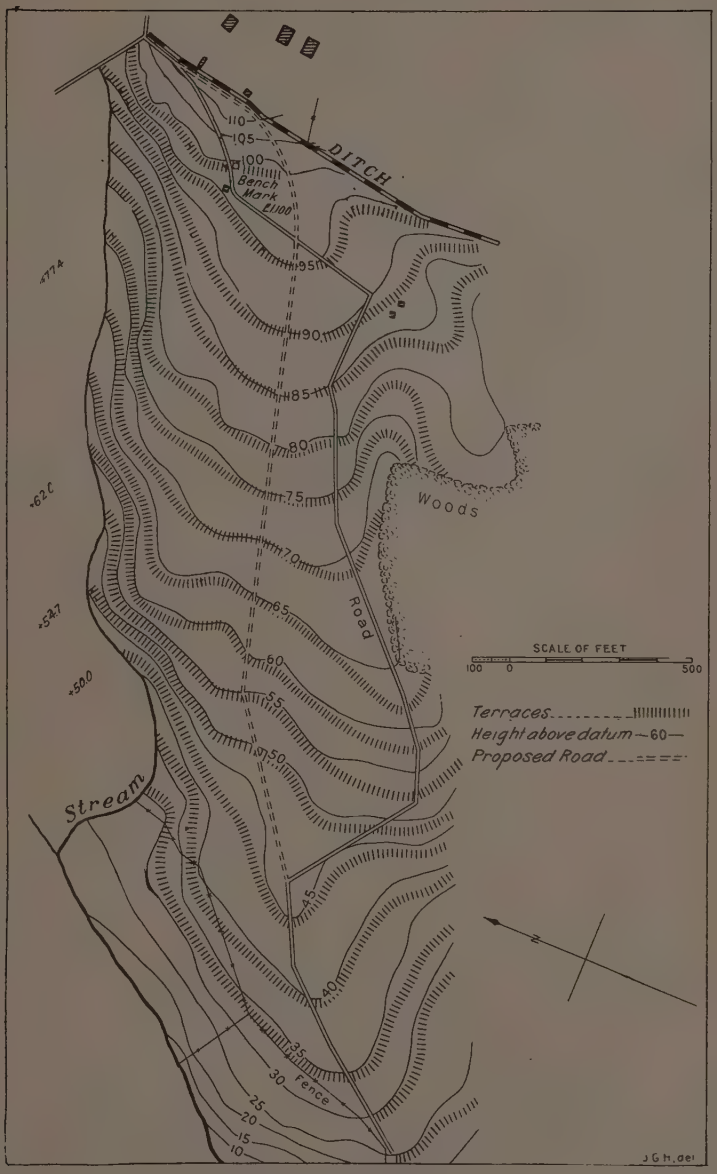


FIG. 13. A terrace design for farm in Cabarrus County, N. C. Report prepared and plan designed by F. R. Baker.

Figure 14 shows a terraced field in Halifax County and illustrates a condition where all of the terraces discharge in one direction. Figure 15 is a photograph taken on this farm while the terraces were being constructed. Figures 6 to 10, inclusive, were also taken on this farm.

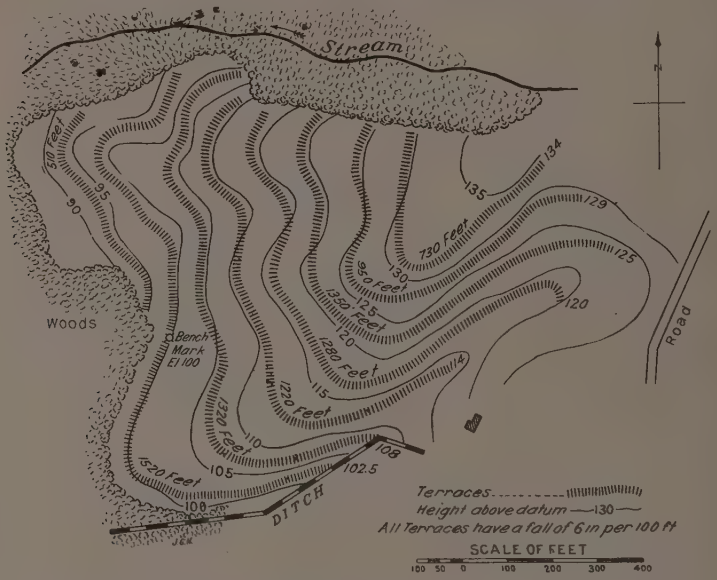


Fig. 14. A terrace design for farm in Halifax County, N. C. Report prepared and plan designed by F. R. Baker.

Attention is again directed to figure 5, which shows the original Mangum terrace. Note the advantages of this type of terrace. It causes no loss in planting space, harbors no weeds, allows any kind of machinery to pass over it, and permits the rows to run in any direction convenient to the farmer.

Never construct a terrace without considering the future. Sometimes they may have to be extended as new conditions arise, or additional terraces may have to be built. Always try to lay them off so that they will fit into any future improvement.

The Level Terrace.

Level terraces are of two kinds, the bench terrace and the broad terrace. The principle, as before stated, is to hold the water on the field, allowing it either to soak in or to evaporate.

The bench terrace (fig. 16) is best suited to mountainous districts, especially the fruit section. However, it is often used where general farming is practiced. One can readily see that this terrace divides

the field into sections, the size of each section being limited to the distance between terraces. This, in a measure, will hinder advanced methods of cultivation, for each section or bench will have to be cultivated independently.

FIG. 15. Showing construction of terraces on a farm in Halifax County, North Carolina.

The broad, level terrace is constructed in the same manner as the falling terrace, except that it is not given fall toward either end. It is best adapted to sections where the rainfall is light or where the soil is in a high state of cultivation, so that the water will be quickly

FIG. 16. Level bench terrace.

absorbed. The bank should be made particularly strong so that it will be able to hold the water. No outlet ditch is necessary and the terraces should not be spaced over three or four feet part, vertical distance.

Filling Gullies.

"What shall we do when a field is hopelessly gullied or when a terrace has to cross a gully?" is often asked. A field in this condition is usually the result of long and continuous erosion. Fields that at present show only slight signs of erosion will soon reach this condition if a preventive is not used and if clean-cultured crops continue to be grown. This is a problem of restoration rather than one of prevention. Nature, to a limited extent, begins such reclamation by supplying a natural growth on these abandoned areas. This natural reclamation is slow, however, and can be assisted by planting favorable growths in the gullies. The flow of water will thus be checked and the soil material deposited; in this way there will be a gradual building

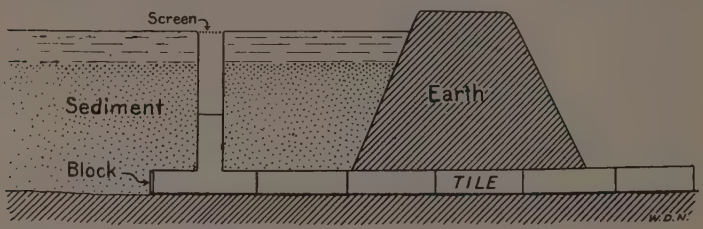


Fig. 17. Showing how to arrange the tile and the dam in a gully.

up of the gully. This method is done, however, at the sacrifice of the surrounding slope, for what the gullies gain the slopes lose. Another and probably better way of building up a gully is by means of a dam. In connection with this dam across the gully is a pipe so arranged as to take away the collected water, leaving the soil behind. This, however, is also done at the sacrifice of the soil from the surrounding fields.

The above methods are both objectionable, as one is concerned not only in filling the gullies, but in checking the erosion on the adjoining slopes. Probably this is most efficiently done by combining the terrace and the dam-and-pipe method.

The dam and pipe are shown in figure 17. The terrace is constructed as usual and where it crosses a gully a dam is built in line and on the same grade as the terrace. When the gully has finally filled there will be a completed and continuous terrace, just as if no gully had been there.

Useful Accessories.

The Farmers' Level.

Figure 18 shows a simple, inexpensive level which can be used by the landowner, the cost of which is about $15, including a rod. The level consists essentially of a set of leveling screws and a telescope to which

is attached a spirit level and which contains in the field of view a horizontal hair, the whole being supported by a tripod. When the bubble of the level is brought to the center by adjusting the leveling screws, the instrument is level, and, in looking over the horizontal hair in the tele-

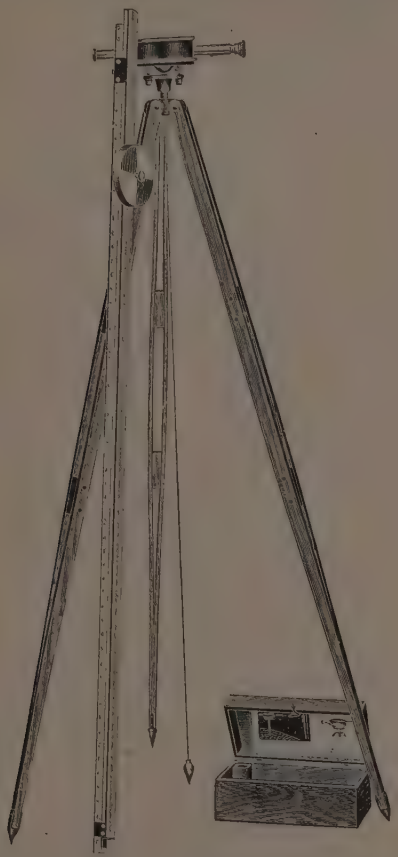


FIG. 18. A simple farmer's level.

scope, one looks along a level line. When this telescope is pointed toward a rod held on the ground the number which the horizontal hair crosses on the rod is called the "rod reading" at that point. It, of course, indicates the height of the level line of sight above the ground at the rod.

A Home-made Level.

Figure 19 shows a handy, inexpensive device for general use on the farm. It consists of a 6-foot pipe with a cross-bar on which rests a

common carpenter's level, and a set of peep sights. It can be revolved around and is suitable for general use on the farm. With the exception of the peep sights this device can be made by any one, but if made by the factory, it will cost about $6 or $7.

How to Use the Level:

Figure 20 represents, in profile, the location for a terrace with stakes 50 feet apart and numbered from 0 to 5 running toward the outlet. To determine the proper route for the terrace, set up and level the instrument at some convenient place where as many as possible of the points on the line to be run can be seen. Instruct the rodman to hold the rod on the ground at station 0, direct the telescope upon it and take the rod reading which, for convenience, we will call 4 feet. Now if the terrace is to have a fall of 6 inches to the hundred feet, station 1 should of course be three inches lower than station 0; station 2, six inches lower; station 3, nine inches, and so on. If the end of the tape is held at station 0, the rodman can move forward 50 feet and shift his rod up and down hill until the telescope reads 4 feet 3 inches, the correct reading for station 1. With this established, have the rodman move forward 50 feet more and get a rod reading of 4 feet 6 inches, the reading for station 2. Continue this operation, letting the rod get 3 inches lower each time, until the end of the terrace is reached or the rod is out of sight, as in bending around a hill. If the rod should get out of sight, just consider the last station established as 0, move the instrument up and repeat the operation, always letting each forward station drop 3 inches lower than the preceding one. It is surprising how quickly the

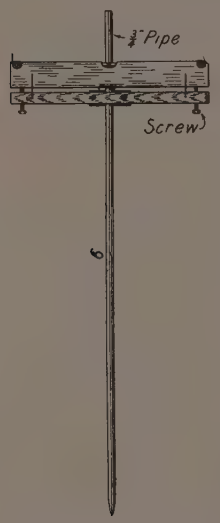


Fig. 19. A home-made level.

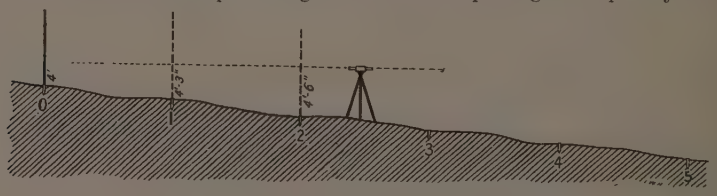


Fig. 20. The use of the level in laying out terraces.

rodman can learn to place his rod the first trial; with a little practice a great number of terraces can be staked out in one day.

In staking up hill, the operation would be the same as just described except that, since the ground constantly rises, the rod readings would, of course, *decrease* 3 inches for each 50-foot station, instead of *increase*.

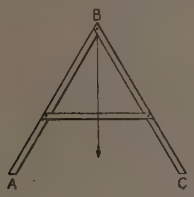
In order that no errors may occur in setting the stakes it is advisable to set down on paper the various rod readings at the successive stations. Following is a simple form of notes. The figures set down are those covering the staking out of the terrace just described.

Station	Rod Readings on First Station		Rod Readings for Succeeding Stations	
	Feet	Inches	Feet	Inches
0	4	0		
1			4	3
2			4	6
3			4	9
4			5	0
5			5	3

NOTE.—Stations are 50 feet apart; therefore, when staking down hill add 3 inches each time to the initial reading, as done in column 3.

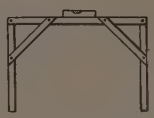
The "A" Frame Level.

Home-made "A" frame levels cost from $2 to $3, and, with proper care, good work can be done with them. The device shown in figure 21 cannot be used during a high wind as the plumb bob will not remain steady. One worker gives the following dimensions for this frame:



21

22



23

FIG. 21. "A" frame used with plumb bob.
FIG. 22. "A" frame used with carpenter's level.
FIG. 23. Rectangular frame used with carpenter's level.

AB and BC are 1 by 3 inches by 16 feet, and AC is 16 feet 8 inches. Figures 22 and 23 are used in connection with a carpenter's level and can be employed under any conditions. Another worker gives the following dimensions and description for the frame shown in figure 23:

Take one piece of perfectly straight 1 by 3-inch lumber 16 feet long. Nail to each end of this 16-foot piece an upright piece 1 by 3 inches, 3½ feet long, for legs, and then with two lighter pieces, ½ inch by 3 inches, put braces to extend from near the foot of each leg toward the center of the frame. Be sure that all joints are straight. Attach a 24-inch carpenter's level in the center. Test its accuracy at a level place by reversing the ends and making adjustments until both are alike. In using this level, it will be found convenient to cut an inch off one leg or else tack a 1-inch block on one to give proper fall to the terrace line. This gradient may be increased or decreased at will.

The Terrace Drag.

One of the best home-made devices for shaping up a terrace after it has been plowed is shown in figure 24, the original idea being taken from the *Progressive Farmer*. Every hillside farmer should have one of these drags on his farm. Says the *Progressive Farmer:*

It is almost self-explanatory. It is a V-shaped scraper so constructed as to aid in throwing the loosened soil toward the center or top of a broad terrace. Special attention is called to the fact that the piece to which the clevis is hitched is set at such an angle with the shorter, rigid side of the V as to give this rigid side a tendency to stay parallel to the turn-plow furrow in which it is run, and the steep side of which furrow further braces this rigid side to

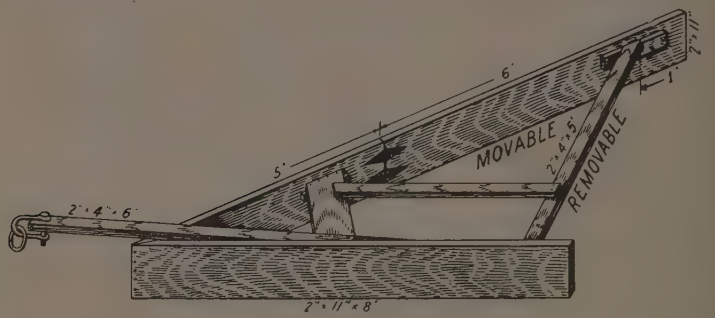


Fig. 24. Terrace drag.

hold the machine in the best position for throwing upwards the soil loosened by several preceding trips of a large turn-plow. Note also that the longer side of this scraper is hinged so that, when its full length is not needed, it is allowed to swing loose by removal of the cross-brace, which is never nailed, and which rests on cleats nailed against the two sides of the scraper. Some care is needed in turning the team to make sure that the hinged part of this arm is not broken off.

Conclusion.

Endeavor has been made to lay stress on the fact that great losses occur each year due to the soil erosion and to point out the methods that can be satisfactorily employed to conserve the soil and prevent further destruction.

The cause of erosion is the lack of ability of the soil to absorb the water quickly, and anything done to promote absorption will lessen erosion. Such methods as can be easily employed are better cultivation, tiling, ditching, and terracing. The first and last are the methods best suited for farming conditions in North Carolina. It is true that a terrace alone will not restore fertility, and the practice of deep plowing with the application of humus is necessary. On the other hand, the application of humus on a worn-out soil with no other protection will be of only temporary benefit, as the work of erosion will continue. The ma-

jority of the farms in the Piedmont section of North Carolina are in need of terracing, and will continue to be as long as clean-cultured crops are grown on the hillsides.

To those who do not advocate the use of terraces it may be said that when the day comes that all soils are brought under a high state of cultivation and farming is conducted along scientific lines, the terrace may be eliminated. That time, however, has not arrived, and to meet the immediate needs of many farmers in the Piedmont section of North Carolina the terrace becomes a necessity.

Where attempts have been made to use terraces and the results have not been favorable, it has usually been that the wrong kind of terrace was used, or that a "level" terrace was not level, or that the fall of the falling terrace was too great. Probably sufficient care and attention were not given to the location and construction.

Of the two terraces, the broad, level terrace is more ideal, but its use is limited to soils in good physical condition. The falling terrace can be more generally used, and is probably best adapted to the conditions found generally in North Carolina. It may be said that the fall of the terrace varies with the state of cultivation, varying between 6 inches in 100 feet and a dead level. The level terrace should be spaced three or four feet apart (vertical distance); and the falling terrace four or five feet apart (vertical distance). A broad mound should be maintained whether a level or falling terrace is used. It will increase the available planting area, it will allow the use of modern labor-saving machinery, and it will allow the enlargement of the fields and make them less irregular. As stated by Ashe:

> There is another aspect of erosion in which the landowner is less personally interested, though it cannot but affect him. A part of the silt and sand from the slopes destroy his bottoms. The other portion of it is swept past in the streams. Some settles in the reservoirs of dams and reduces the value of the water-power of the streams and affects the industries dependent upon them. A portion settles further down in the channels of the navigable rivers, lessening their value and rendering navigation hazardous, while still another portion forms a part of the silt bars in the harbors, reducing their depth and necessitating constant dredging to maintain depth of harbor. The silt, clay and sand burden of the streams of the Piedmont section probably amounts to more than 4,000,000 tons a year, the greater portion of which comes from the farms. The welfare of the entire State demands that this enormous quantity of soil, rich in humus and in soluble plant food, be retained on the farms to maintain their fertility and not permitted to be washed into the rivers to destroy their earning value. Natural resources, when once destroyed, cannot be replaced. The civilization of a people is determined by the advantageous use they make of the gifts of nature.